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January 14, 2008

Delores Brown, Chief
Director of Environmental Compliance
California Department of Water Resources
3251 S. Street, Sacramento, CA 95816
**Via email: delores@water.ca.gov**

**Re: Comments on the Draft Environmental Impact Report (DEIR) for the Monterey Amendments to the State Water Project Contracts, including the Kern Water Bank Transfer and associated actions as part of a Settlement Agreement (Monterey Plus).**

Dear Ms. Brown:

I write on behalf of the California Water Impact Network (C-WIN), a statewide nonprofit organization dedicated to ensuring that California's water resources are allocated in an equitable and environmentally sensitive manner. This letter is also submitted on behalf of the California Sportfishing Protection Alliance (CSPA). The proposed project represents a fundamental alteration of the State Water Project (SWP). It is with this in mind that we submit the following comments on the Draft Environmental Impact Report (DEIR).

In general, we believe the DEIR has lost sight of the environmental catastrophe that has been accelerating in tandem with the interim implementation of this project. Since 1996, the Sacramento-San Joaquin Delta has descended into an ecosystem crash. A number of critical species have exhibited record low abundance numbers. Recent increases in pumping from the Delta by the SWP and the federal Central Valley Project (CVP) has been identified as a primary cause of the Delta's decline. Of particular note are marked increases in winter and spring exports of Article 21 and turnback pool water, brought about in part by the project currently under review.

Not only has the proposed project contributed to the decline of the Delta, it has facilitated massive urban sprawl in Southern California, where multiple developments are now moving through the planning process, all relying to varying degrees on water that the SWP cannot reliably deliver. In this respect, the project's proposed changes to Article 18 and Article 21 are of particular concern. The elimination of Article 18(b) and the Urban Preference previously contained within Article 18(a) eliminate critical drought protections for urban areas and remove provisions that empower DWR to reduce project entitlements to reflect the safe yield of the project <u>without compensating contractors at public expense</u> for the water that they "lost." At the same time, the proposed deletion of Article 21(g)(1)'s prohibition against the use of "surplus" water to support permanent development threatens to make permanent the newest embodiment of the "paper water" problem.

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By handing the Kern Water Bank (KWB) over to a joint powers authority controlled by private interests, DWR is giving up yet another tool that could be used to hedge against statewide shortages. If approved, this transfer would fundamentally change the purpose of the bank and would eliminate public accountability over that resource. This move could not come at a worse time in California's water history. Just as we need such resources to protect established uses and the public trust, the project proposes giving away the largest groundwater bank in the world.

Circumstances have changed dramatically since the Monterey Agreement was negotiated. What may have seemed like a good bargain for the people of California in 1995 is now desperately out of sync with reality. *Planning and Conservation League v. Department of Water Resources* (2000) 83 Cal. App. 4th 892 ("PCL v. DWR") and the subsequent Settlement Agreement compel DWR to render a new decision, unclouded by past actions. We believe that DWR has the courage and foresight to resist the inertia associated with this project, and we urge DWR to take a hard look at the costs and benefits of this project for the people of California and the State's precious public trust resources.

(We also incorporate herein the comments made on behalf of C-WIN by (a) Carolee Krieger at the public forum in Ventura, California, held on December 4, 2007, as well as the letter and exhibits she submitted at that time; and (b) Michael Jackson at the public forum in Quincy, California on November 29, 2007. We further incorporate all other comments submitted by other concerned parties.)

## I. The DEIR Does Not Accurately Disclose DWR's Responsibility to Make a New Decision.

The primary purpose of this EIR is to inform DWR's decision whether to approve, modify, or discard the project or components of the project. However, section 1.2 of the DEIR uses language that obscures this clear purpose. Specifically, at page 1-1, the DEIR states that DWR will use the EIR to "decide whether to *continue* operating under the proposed project...or to decide to implement one of the alternatives to the proposed project." (Emphasis added.) This language suggests that the interim implementation of the project has undergone prior environmental review. This, as DWR is well aware, is not the case. The interim operation of the project will expire as soon as DWR files its return to the Superior Court's writ of mandate. This section should instead explicitly articulate DWR's real responsibilities vis-a-vis the project and its alternatives. Specifically, DWR must make a new decision whether to approve implement aspects of the project, including the Monterey Amendments, the Settlement Agreement, and the transfer of the Kern Fan Element; whether to approve and implement an alternative to the project and/or more substantial mitigation for the project; or whether to approve no project at all.

This semantic choice is no small matter. Throughout the document, as is demonstrated below, it appears as though DWR is not fully committed to its role as a decision-maker.

## II. The DEIR Fails to Accurately Describe Fundamental Aspects of the Project and Omits Critical Information from the Project Description.

### a. Subsequent drafts should more accurately explain the role of Article 18(b) in the pre-project contracts.

The DEIR suggests in several places that, under most circumstances, there would be no effective difference between implementation of Article 18(b) and operations under the Monterey Amendments. For example, at page 2-16, the DEIR suggests that even if article 18(b) were implemented, it would have no effect on water deliveries in years where the project yield exceeded the minimum safe yield:

> The effect of an implementation of Article 18(b) would have been to reduce the number of years when agricultural contractors would have to take shortages in years when Article 18(a) was applied to SWP deliveries. It would not, however, have altered the amount of water that the Department delivered to the contractors in the many years when more than the minimum SWP yield was available in the SWP system. Instead, such water would have been delivered to the contractors under Article 21.

Similarly, and for similar reasons, the DEIR suggests that article 18(b) is superfluous language at page 4-5:

> [O]nce the agriculture first shortage provision was eliminated, [article 18(b)] would no longer be needed to protect agricultural water users from excessive shortages. With the elimination of the agricultural first shortage provisions, it no longer mattered whether a shortage was a temporary one or a permanent one, since the allocation of the available supply would be the same in either situation.

Again, at page 6-51, the DEIR admits that one of the historical operations analyses used to examine the effects of the water supply management aspects of the project does not account for altered water allocation procedures. The DEIR offers several reasons for this failure. Most importantly, the DEIR asserts: "the altered allocation procedures provided for by Articles 18 and 21 result primarily in a shift in deliveries from one contractor to another and do not affect total deliveries..." (DEIR at p. 6-54.)

These assertions are misleading in many respects, most obviously because, as mentioned in nearby passages (e.g., at p. 2-17), the Monterey Amendments altered Article 21 to remove language precluding delivery of Article 21 water if "such delivery would tend to encourage the development of an economy within the area served by such a contractor which would be dependent upon the sustained delivery of water in excess of the contractor's maximum annual entitlement."

The original Article 18(b) served as a safety valve, allowing DWR to lower the project yield to reflect the extent to which water can be delivered on a sustainable basis. If

article 18(b) was invoked and the original Article 21 prohibition against the use of surplus water to support permanent economies were retained, the entire system would be able to operate sustainably and the paper water problem would be completely eliminated.

In contrast, if Article 18(b) and 21(g)(1) are eliminated, Article 21 water, which would be no more predictable than it was before the Monterey Amendments, can be used to fuel permanent economies at the discretion of local land use decision-makers. DWR acknowledges that Article 21 water is "highly unpredictable and unreliable" in its own 2005 Reliability Report.[1]

Article 18(b) is not just a protective device for agricultural contractors, nor does it become superfluous upon the elimination of Article 18(a). Article 18(b) paired with Article 21(g)(1) is an important safety valve that could operate to maintain the long-term sustainability of the project. It must be described as such in subsequent drafts of the EIR

**b. The role of Article 18(a) in the pre-Monterey contracts should also be more accurately explained.**

In addition to operating as a shortage allocation mechanism, Article 18(a) served as a constraint on transfers that might have had growth inducing impacts. In the absence of the Monterey Amendments, entitlement transferred from an agricultural contractor to an M&I contractor would have retained its agricultural priority (or lack thereof). This limited the use of such transferred water to support permanent developments, as it could not be relied upon in times of shortage. This should be clearly disclosed in subsequent drafts.

**c. The EIR should explain DWR's right to so-called "surplus water."**

The EIR states that it delivers surplus water when all of the following conditions exist "the SWP's share of San Luis Reservoir is full, or projected to be full in the near term; other SWP reservoirs are full or at their storage targets, or the conveyance capacity to fill these reservoirs is maximized; the Delta is in 'excess' conditions []; Table A deliveries are being fully met; and the Banks Pumping Plant has spare capacity." (DEIR at p. 2-17.)

Yet, nowhere does the DEIR explain what right the SWP has to extract so-called surplus water in the Delta. These waters, which are being extracted from an ecosystem in crisis, are subject to the public trust. The public is entitled to a description of the basis upon which DWR distributes this resource to SWP contractors. As is demonstrated below, delivery of Article 21 water has increased considerably in recent years. Yet, given the continuing decline of the Delta ecosystem, from which Article 21 water is taken, it is clear that these deliveries are not truly "surplus" to the needs of the ecosystem. DWR should explain how, if at all, their operational definition of surplus comports with the ecological reality in the Delta.

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[1] Attachment 1, DWR, The State Water Project Delivery Reliability Report 2005 (2006) at p. 15.)

The scoping comments submitted by Robert C. Wilkenson previously pointed out the need for such a disclosure, emphasizing that "[i]f 'surplus' water is unavailable to DWR dues to uses by more senior appropriators and/or upstream users exercising their legal claims to water and/or due to water quality environmental, and other legal requirements, the SWP's ability to deliver water will be impacted." (DEIR, Appendix, B, Comments of Robert C. Wilkenson at p. 5.)

**d. The DEIR fails to clearly disclose Article 53's proposed privatization of the SWP.**

Section 4.4.2 at page 4-6 generally describes that the addition of Article 53 to the long-term water supply contracts will allow for the permanent transfer of 130,000 AF of Table A entitlement on a willing buyer/willing seller basis to M&I contractors or non contractors. This section, which is one paragraph in length, does not fully explain the implications of Article 53. For instance, Article 53 also allows for the permanent transfer of entitlements among contractors above and beyond 130,000 AF with little state oversight. This, in effect, allows for the wholesale privatization of the SWP.[2]

The text at page 4-6 does explain that Article 53 also provides for the permanent retirement of 45,000 AF of Table A entitlements. However, to avoid giving the false impression that this retirement will reduce overall deliveries by 45,000 AF, the section should also explain that only a portion of that amount had been historically available to the "donor" prior to its retirement.

**e. The DEIR does not describe the practical effect of the water management practices described in Section 4.4.4.**

Together, all of the water management practices described in section 4.4.4 ensure that Delta exports remain at their maximum during all times of the year. This should be clearly disclosed.

For example, the Turnback Pool is described generically as a mechanism that "enables contractors to be partially compensated for unused allocated Table A water purchased by other SWP contractors and increases the likelihood that any excess allocated water would be available to other contractors early enough in the year to be managed and used more efficiently." (DEIR at p. 4-8.) Although this is an accurate description of one aspect of the Turnback Pool, the Pool also serves to motivate contractors to ask for their full entitlement even if they do not need it or have nowhere to store it, because they can use any excess the next year and/or sell it on the market.

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[2] DEIR Appendix C, Kern County Water Agency Contract Amendment No. 23, at p. 42-43, Art. 53(h).

In part as a result of the project-related changes to water management practices, demand for Article 21 water, particularly from urban contractors, has increased since the interim implementation of the Monterey Agreement.

Through a Public Records Act request, C-WIN obtained monthly delivery data for the two largest SWP agricultural contractors (Kern County Water Agency & Tulare Lake Basin Water Storage District) and the two largest M&I contractors (Metropolitan Water District of Southern California and Santa Clara Valley Water District) from 1980 to 2007.[3]

Utilizing this data, Figure A, charts the delivery of "surplus" water (pre 1994) and Article 21 water (post-1994). Each column represents a year of deliveries, from 1980 to 2006. Each column is, in turn, broken down to show the monthly contribution to the total. Most critically, during those years in which so-called surplus or Article 21 water is made available, the post-Monterey period shows a clear trend toward delivering that water earlier in the year.

**Figure A**
**Delivery of Surplus & Article 21 Water Delivered to KCWA, TLBWSD, MWDSC & SCVWD**

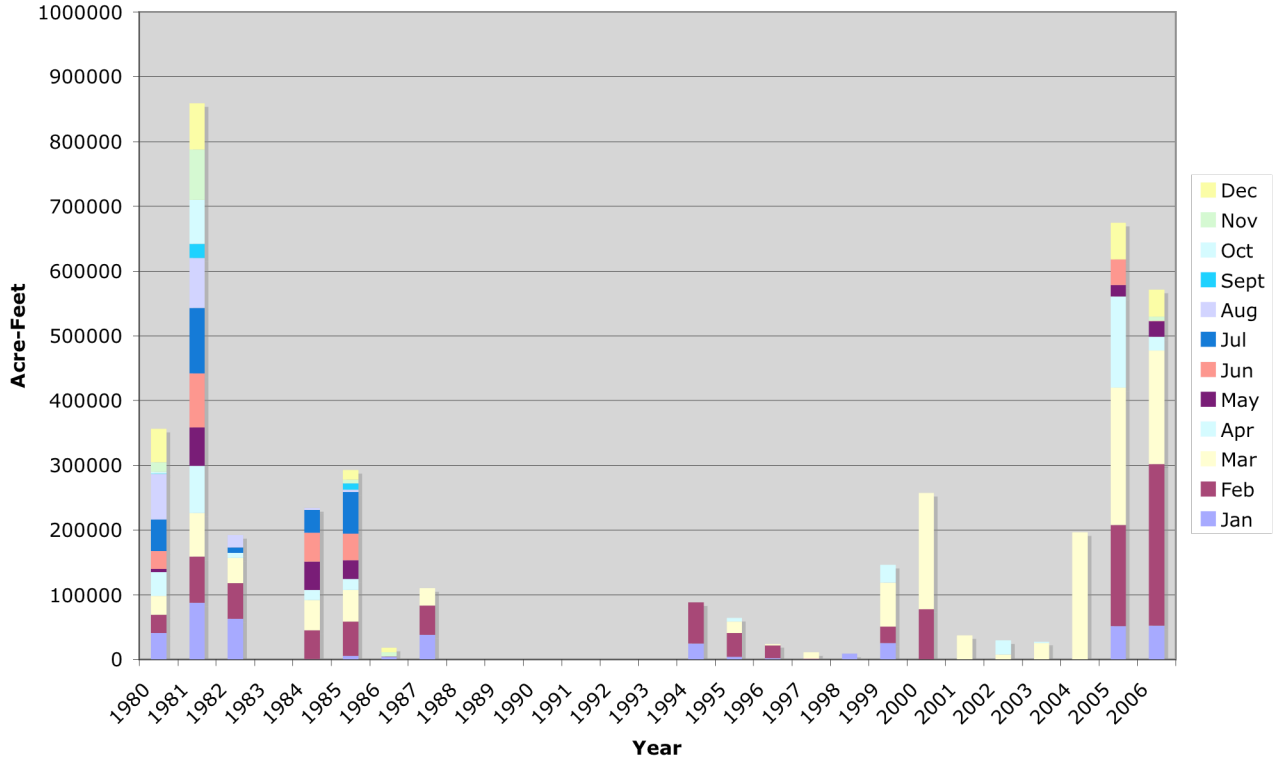



Figure B charts the deliveries of surplus and/or Article 21 water to the two largest M&I contractors only. This chart clearly demonstrates a huge spike in post-Monterey

[3] That raw data is attached to this letter as two electronic files, Electronic Attachment A & B. (No hard copy has been attached.)

deliveries of "surplus" water to M&I contractors, particularly in January, February, and March.

**Figure B**
**Deliveries of Surplus & Article 21 Water to MWDSC and SCVWD for M&I Purposes**

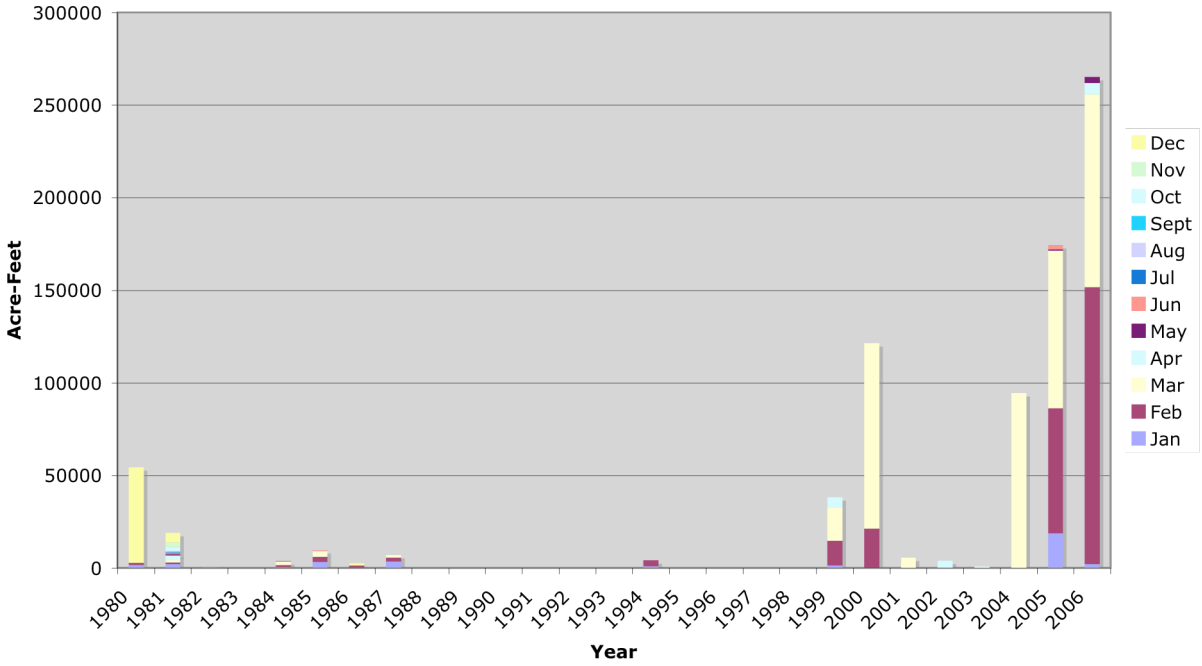
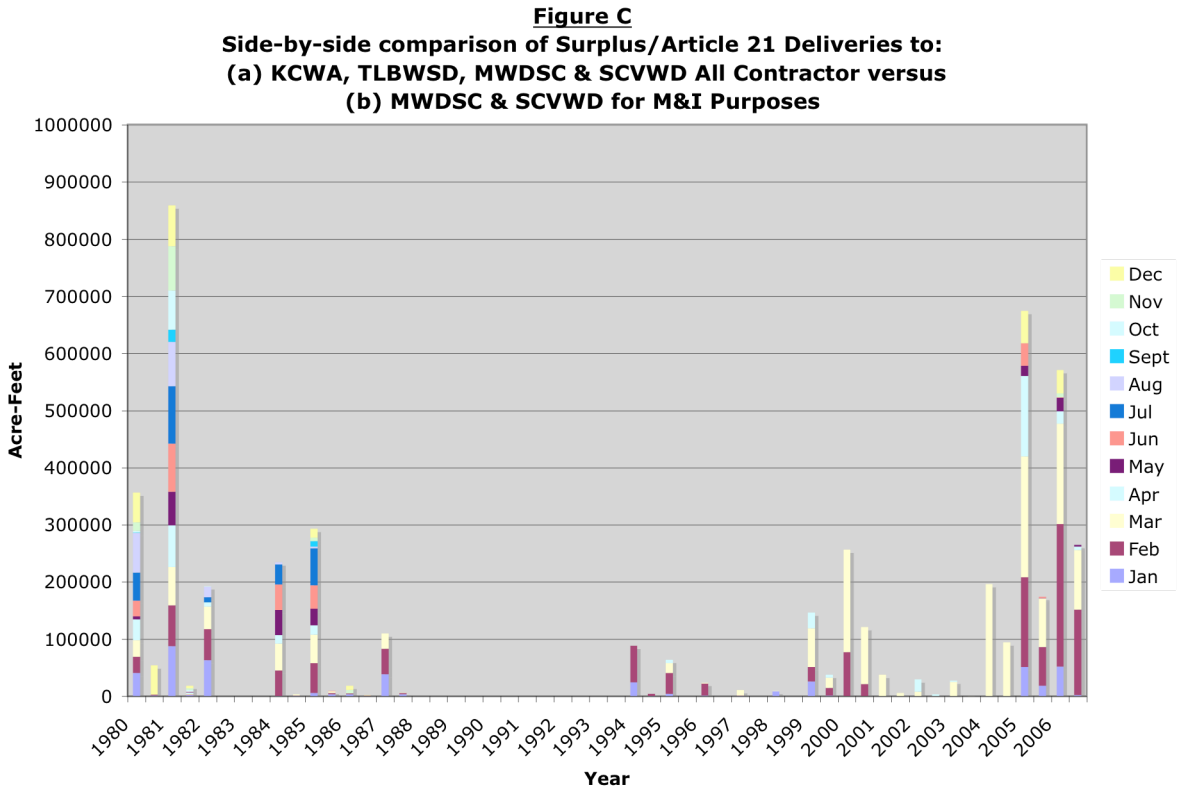



Figure C places the information from Figures A and B side-by-side to depict the relative contribution of the M&I deliveries to the total. Noticeably, prior to the interim implementation of the Monterey Amendments, M&I demand for surplus water constituted a negligible fraction of overall surplus water deliveries, while post-interim implementation, M&I deliveries of "surplus" water were considerable.




This analysis should be repeated by DWR for all contractors and disclosed in the DEIR. To the extent that DWR asserts this shift in timing can be attributed to other causes, DWR should explicitly demonstrate the relative contribution of those other explanations for seasonal shifts in Article 21 demand.

## III. <u>There Are Fundamental Problems with the DEIR's "Baseline."</u>

### a. The DEIR confuses the concept of a "baseline" with the concept of a "no project alternative."

According to CEQA Guideline § 15125(a), an EIR must "include a description of the physical environmental conditions in the vicinity of the project, as they exist at the time the notice of preparation is published, or if no notice of preparation is published, at the time environmental analysis is commenced, from both a local and regional perspective." Critically, "[t]his environmental setting will normally constitute the baseline physical conditions by which a lead agency determines whether an impact is significant." (*Id.*)

The DEIR utilizes three different points in time as landmarks for its analyses: 1995, 2003, and 2020. As a threshold mater, it no longer makes sense to utilize 2020, which is a scant

12 years away, as the outside limit of DWR's analysis. Other DWR documents analyze scenarios extending to 2035.[4]

The DEIR indicates that the baseline "condition that existed in 1995 was adjusted...to include events that are expected to occur over time unrelated to the Monterey Amendment or the Settlement Agreement." (DEIR at p. 5-2.) For example, the baseline for 2020 includes "[o]ther changes and transfers unrelated to the Monterey Amendment that occurred since 2003 or are anticipated to occur by 2020 (including 100,000 AF of Table A transfers from MWDSC to Coachella Valley WD and Desert WA)." (DEIR p. 5-3.) Similarly, Appendix F to the DEIR indicates that "the 2003 and 2020 Baseline scenarios include inputs such as increased Table A amounts and water demands to capture immutable and non-discretionary changes that occurred from 1995 to 2003 and that will occur in the future." (DEIR, Appendix F, at p. 4.)

There are several fundamental problems with this approach to designing the baseline. First, the DEIR does not provide a detailed explanation of the exact "anticipated" and "future" changes that are in fact included in the baseline scenarios. The most detailed description we could locate is provided at page 5-2, which states:

> Thus, the baseline for the Monterey Plus EIR will be continued operation of the SWP in accordance with the long-term water supply agreements but adjusted to include events that are expected to occur over time that are not related to [the] Monterey Amendment and the Settlement Agreement. The events expected to occur between 1995 and 2020, unrelated to the proposed project, include increased population growth and urban development in California, increased demand for water in the SWP service area and elsewhere and certain Table A transfers.

(Emphasis added.)

Second, as a general matter, it is inappropriate to include anticipated future changes, such as anticipated population growth and urban development, in a baseline scenario. That is the role of the "no project" scenario under CEQA. This is made explicitly clear in CEQA Guideline § 15126.6(e), which states in pertinent part:

> (1) The specific alternative of "no project" shall also be evaluated along with its impact. The purpose of describing and analyzing a no project alternative is to allow decisionmakers to compare the impacts of approving the proposed project with the impacts of not approving the proposed project. The no project alternative analysis is not the baseline for

[4] DWR uses this 2020 end date as an excuse for not thoroughly analyzing the impact of climate change on project operations, asserting that "the extent to which these effects will be felt between now and 2020 has not been studied and remains unknown." (DEIR at p. 12-12.) Yet, in the subsequent paragraph, DWR acknowledges that between 2035 and 2064, studies indicate that Table A supplies could decline by up to 10 percent.

> determining whether the proposed project's environmental impacts may be significant, unless it is identical to the existing environmental setting analysis which does establish that baseline (see Section 15125).
>
> (2) The "no project" analysis shall discuss the existing conditions at the time the notice of preparation is published, or if no notice of preparation is published, at the time environmental analysis is commenced, as well as what would be reasonably expected to occur in the foreseeable future if the project were not approved, based on current plans and consistent with available infrastructure and community services....

(Emphasis added.)

By describing the baseline as a condition that includes certain changes that "would be reasonably expected to occur in the foreseeable future if the project were not approved," the DEIR has fundamentally corrupted the impact analyses in Chapters 6 and 7. By skewing the baseline to reflect, for example, increased demand caused by these anticipated future changes, the project's relative impact on the environment may be masked, thereby resulting in findings of no significant impact where impacts might otherwise surface. Practically, this has impact of narrowing the categories of environmental impacts that are subject to comparison during the alternative analysis.

At the very least, the methods/baseline section must be clarified to more clearly explain what future anticipated changes are included in the baseline and why those impacts have been included in the baseline, rather than only in a no project alternative. In addition, the baseline should be adjusted to more faithfully reflect the role of the "baseline" scenario under CEQA.

**b. The baseline scenarios fail to account for the manner by which the Monterey Agreement changed contractor demand for water.**

As described above at Part II(g), deliveries of Surplus/Article 21 water, particularly early in the year, have increased since the interim implementation of the project. This is presumably a reflection in changed patterns of demand. The baseline scenario fails to account for these changed patterns of demand.

**c. The historical baseline scenarios utilized in the DEIR fail to back out certain aspects of the Monterey Agreement.**

The DEIR appears to fail to back out all aspects of the project from the various baseline scenarios described in Chapter 5. For example, while historical study #1 does back out of the baseline the changed allocation scheme and the Table A retirements, it does not attempt to back out of the baseline the project's changes to contractors' ability to store water outside their service areas, changes to the Turnback Pool, or the deletion of Article 21(g)(1), which precluded use of surplus water to fuel permanent economies. Again, this skews the analysis so as to minimize the difference between the baseline and the project.

## IV. The DEIR Inappropriately Relies Upon CalSim II as a Tool for Environmental Impact Analysis.

### a. It is inappropriate to rely upon an optimization model as the primary tool for the measurement of environmental impacts under CEQA.

CalSim II is an optimization model that, on its own, cannot satisfy CEQA's mandate to analyze and disclose the environmental impacts of a proposed project. CalSim II does enable programmers to include certain environmental requirements as constraints (e.g., Delta water quality standards). However, even assuming all relevant constraints have been added to the code (an assumption which is refuted below), these constraints operate as a ceiling on deliveries. Although CalSim II will not model deliveries above this threshold, thereby ensuring compliance with those environmental constraints contained within the code, it is the nature of an optimization model to assume that deliveries will reach all the way to this ceiling, causing the maximum environmental impact permissible under the laws/regulations/requirements that happen to be coded into the program. Stated another way, CalSim II never allows the DEIR to truly measure environmental harm beyond simply projecting how to maximize deliveries without violating the incorporated environmental constraints.

This approach is at odds with the fundamental purpose of CEQA, which is to disclose to the public the spectrum of environmental impacts caused by the project vis-a-vis the no-project alternative and other alternatives. A report produced by the Natural Heritage Institute entitled "An Environmental Review of CalSim-II" summarizes this flaw succinctly by "call[ing] into question the use of CalSim-II as a tool for environmental impact assessment, since it is changes in the environment associated with specific projects and not the satisfaction of arbitrary constraints which is the critical focus of environmental review."[5]

### b. Subsequent drafts of the EIR should provide a more balanced summary of the Strategic Review's findings.

At p. 5-10, the DEIR attempts to summarize the findings of the CALFED Science Program's peer review of CalSim II. However, the DEIR does not faithfully disclose the severity of the critique presented in the Strategic Review. For example, the bullet points included at the bottom of p. 5-10 suggest that the findings of the Strategic Review were all positive. They undoubtedly were not. The public is entitled to a more balanced summary of the Strategic Review.

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[5] Attachment 6, J. Payne & D. Purkey, An Environmental Review of CalSim-II: Defining "Full Environmental Compliance" and "Environmentally Preferred" Formulations of the CalSim-II Model" (November 2005), at p. 14.

**c. CalSim II does not include critical constraints regarding mandated Delta fish species protection or ecosystem restoration actions.**

CalSim II contains no code to account for the myriad of flow, habitat, and water quality requirements mandated by federal and state species protection statutes. As a result, there is, again, an "aura of unreality,"[6] about all aspects of this DEIR that rely upon CalSim II. In the face of potentially the most significant set of environmental cutbacks mandated in the history of the SWP -- the interim delta smelt protection order -- this DEIR proceeds without incorporating any Endangered Species Act requirements into its modeling. Given the model's failure to reflect this significant environmental constraint on operations, CalSim II is not suited to the task at hand, namely, the disclosure of the project's impacts on the environment.

Nor does CalSim II possess any capacity to account for or measure the project's impacts upon efforts to restore the Delta watershed and its fisheries. By focusing so completely on a handful of largely outmoded environmental constraints, CalSim II fails to evaluate how the pumping changes engendered by the project will impede ongoing or future restoration programs.

Performing a more appropriate analysis is feasible. For example, in separate comments submitted to DWR on behalf of the Citizens Planning Association of Santa Barbara County, Dr. Arve Sjovold indicates that, although there are no routines in CalSim II to model reverse flows that contribute to delta smelt entrainment, there is sufficient information to allow the model to predict when such flows would occur. This information could be used to incorporate a smelt-protection constraint on Delta pumping based on anticipated reverse flows.

Alternatively, subsequent drafts of the EIR could turn away from the DEIR's heavy reliance on modeling in favor of more traditional approaches to impact analysis, such as hands on environmental monitoring, analysis by fisheries experts, etc.

**d. Other problems with the use of CalSim II in this document.**

- **CalSim II assumes perfect supply and perfect demand.** The notion of perfect supply is based on the erroneous assumption that groundwater can always be obtained to augment upstream SWP supply. Among other things, operating under this assumption risks causing impacts to ecosystems dependent upon the groundwater basins in the areas of origin. The notion of perfect demand is also problematic.[7] Prior to the interim implementation of the Monterey Agreement,

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[6] *PCL v. DWR*, 83 Cal. App. 4th at 913.

[7] The DEIR purports to address previous criticisms regarding the overestimation of demand by revising demand estimates as described in Appendix F. (See page 5-11.) However, according to Appendix F, although the categories of demand may have

contractors did not demand their full Table A amounts every year. The project has offered contractors opportunities to take and store water when they otherwise would have had nowhere to put it. The assumption by CalSim II that demand is always constant under all modeling scenarios makes it impossible for the CalSim II runs utilized in this EIR to truly measure the impact of the demand-altering aspects of the project.

- **Actual operations are not faithful to legal constraints**. In reality, operations do not always comply with legal constraints, threatening the ecosystem values protected by these constraints.[8] CalSim-II has no way of accounting for this reality.

- **CalSim II has not been calibrated, nor is there any way to account for uncertainty in the model's operation.** These and other flaws in CalSim II have been pointed out to DWR on many occasions. Given CalSim II's well-documented shortcomings, DWR should consider imposing upon all CalSim II model predictions a margin of safety that would prevent harm to the environment until a more accurate model is available.

Subsequent drafts of the EIR should address and/or disclose all of the above issues. Attempts should also be made to adjust CalSim II (or another model) to account for **all** Delta environmental constraints. In addition, DWR could post-process the CalSim II results to build in a margin of safety to account for Delta health and restoration and the model's uncertainties.

## V. The Project's Impacts Upon SWP Deliveries.

### a. The Final EIR should include a full description and analysis of the impact of the delta smelt/OCAP decision on the delivery reliability of the SWP.

Conspicuously absent from Section 6.3 (Changes in SWP Operations Since 1995 Unrelated to the Proposed Project) is any mention of the Delta Smelt/OCAP case, arguably the most significant environmental constraint upon the SWP moving forward. Although the final interim order imposing conditions upon Delta pumping facilities did not come out until December 14, 2007, after the DEIR was issued, the federal court's summary judgment decision was issued on May 25, 2007, many months before the DEIR.[9]

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changed, overall demand of the SWP remained constant across all modeling scenarios. (*See* Appendix F, at p. 11.)

[8] *See generally*, Payne & Purkey, An Environmental Review of CalSim-II, *supra* at n. 5.

[9] Attachment 7, *NRDC v. Kempthorne*, 1:05-cv-1207 (EDCA), Doc. 560, Interim Remedial Order Following Summary Judgment and Evidentiary Hearing, dated Dec. 14,

Regardless of the timing of the decision vis-a-vis the issuance of the DEIR, it is beyond dispute that the final order is significant enough to merit discussion in the final EIR and/or a supplemental EIR. For example, a recent article in the Sacramento Bee indicated that on December 28, 2007, shortly after the issuance of the final interim order, Delta exports were cut in half to protect the smelt from entrainment.[10] Such significant cutbacks were predicted by DWR's own scientists well before the issuance of the final order by the federal court. On July 9, 2007, DWR's Chief of Project Operations Planning Branch, John Leahigh, declared that under the interim remedy actions proposed by the United States Fish and Wildlife Service, as supported by DWR, SWP 2008 deliveries would be reduced anywhere between 8% (91,000 AF) to 27% (305,000 AF) from a baseline delivery of 1.15 MAFY in a dry year; and from between 8% (252,000 AF) and 31% (305,000) from a baseline of 3 MAFY in an average year.[11] A recent Metropolitan Water District of Southern California staff report indicated similarly dramatic cutbacks would result from the delta smelt decision and that the project worsened the impact of these cutbacks upon MWDSC vis-a-vis the baseline.[12]

Although it is not exactly clear how the types of cutbacks imposed by way of the interim remedy will translate into permanent changes to operations under the not-yet-issued Biological Opinion (BiOp), it is safe to say that the OCAP BiOp will impose significant, substantially similar, cutbacks. Although it may not be possible to precisely model the nature of these future cutbacks, the likelihood of their imposition should be disclosed and thoroughly discussed. The types of cutbacks ordered during the interim period could be evaluated as an example of the types of cutbacks that might be ordered on a permanent basis.

Subsequent drafts of the EIR should note, in particular, the timing of cutbacks that will be needed to avoid jeopardy of and restore the delta smelt. Specifically, those cutbacks are and will probably continue to focus on winter and spring pumping, exactly the period of time during which project-induced pumping has taken place in the past.

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2007; Attachment 8, *NRDC v. Kempthorne*, Doc. 323, Order Granting In Part and Denying In part Plaintiffs' Motion for Summary Judgment, dated May 25, 2007.

[10] Attachment 9, Matt Weiser, Delta Water Exports Halved, SacBee.com, December 29, 2007.

[11] Attachment 10, *NRDC v. Kempthorne*, Doc. 398, Declaration of J. Leahigh, dated July 9, 2007, at ¶¶ 6. 36-37.

[12] Attachment 11, MWDSC, Update on Monterey Amendment, PowerPoint Presentation to the Water Planning and Stewardship Committee, Agenda Item 6(e), presented Jan. 7, 2008, dated Jan. 9, 2008, at slide 5.

**b. The results of the analyses contained within Chapter 6 must be reconciled with observed increases in deliveries.**

The DEIR fails to clearly explain, in a manner intelligible to a member of the general public, how the results of various studies comport with observed increases in pumping. For example, how can Study No. 2, which concluded that from 1996 to 2004, the project resulted in increased deliveries of only 44,000 AF (total), be reconciled with observed increased deliveries from the project as a whole, and, specifically, increases in winter and spring deliveries of 49% and 30% respectively?[13]

Subsequent drafts of the EIR should contain a clear explanation of how these large annual and seasonal changes can be explained, if they are not caused by project operations.

**c. The DEIR should clearly disclose the seasonality of the increase predicted by in Study No. 3**

Study No 3 indicates that in the future, the project will increase annual deliveries of SWP water by 50,000 AF/year. (DEIR at 6-64.) Future drafts of the EIR should clearly disclose the months during which these increases are expected to occur.

## VI. The Impact of the Project on the Environmental Water Account.

**a. The DEIR should more clearly explain what the EWA is and how it operates, including an explanation that the EWA causes increased pumping at Banks.**

Nowhere does the DEIR clearly explain how the EWA operates. A clear, complete, and accurate explanation of the EWA program should be included in any subsequent drafts. Some clear language on the issue can be found in the Environmental Defense report: "Finding the Water."[14]

In particular, subsequent drafts of the EIR should take care to faithfully disclose that the EWA causes increased Delta exports by compensating contractors for water that could otherwise be withheld under various laws. For example, at p. 6-14, the DEIR cryptically states that "[t]he result of this aspect of EWA operations is to reduce the amount of time when all SWP reservoirs south of the Delta are full or at their storage targets, all SWP demands are being met, and Banks pumping can be reduced. Banks pumping would

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[13] Attachment 12, The Bay Institute, et al., Petition to the State of California Fish and Game Commission and Supporting Information for Listing the Delta Smelt (*Hypomesus transpacificus*) as an Endangered Species under the California Endangered Species Act (Feb. 7, 2007) at p. 25.

[14] Attachment 13, Environmental Defense, "Finding the Water: New Water Supply Opportunities to Revive the San Francisco Bay Delta Ecosystem" (2005) at p. 5.

generally not be reduced until the EWA debt has been repaid and SWP storage in San Luis Reservoir is physically full." This language is too vague.

**b. The DEIR improperly classifies the impact of increasing EWA costs as an "economic" not an "environmental" impact.**

The DEIR admits that implementation of the project could increase EWA costs by about 10 percent in years when curtailments occurred, but states that "because this is an economic and not a physical environmental impact, no significance conclusions were drawn." (DEIR at p. 7.1-61.) This is pure fiction. Impacts upon EWA funding directly translate into environmental impacts. For example, because the EWA has been chronically underfunded, it has failed to function as originally envisioned and has limited the willingness of responsible agencies to fully implement recommended fish protection actions.[15] On this topic, we incorporate the attached December 10, 2007 comment letter from the Natural Resources Defense Council to the Bureau of Reclamation Re: the Draft Supplemental EIS/EIR for Extending the Environmental Water Account, as well as a number of exhibits to that letter.[16]

The past performance of the EWA and the environmental impacts that have resulted from underfunding the program must be considered in subsequent drafts of the EIR. *See Laurel Heights Improvement Association v. Regents of the University of California*, (1988) 47 Cal. 3d 376, 420 ("Because an EIR cannot be meaningfully considered in a vacuum devoid of reality, a project proponent's prior environmental record is properly a subject of close consideration in determining the sufficiency of a proponent's promises in an EIR.").

## VII. The Project's Impacts Upon Groundwater Resources in the Area of Origin Are Not Disclosed.

As discussed above, CalSim II is hard-wired to assume perfect supply. In part, this results in an assumption that the SWP can access groundwater from the Sacramento River basin. However, the SWP has no right to this groundwater, which lies in an unadjudicated basin. There is no mention in the DEIR of the potential environmental problems that may result from tapping into this aquifer and/or of the fallacy of relying on this water as a source of SWP supply. Both are fundamental flaws that must be addressed.

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[15] *See* Finding the Water, *supra* note 14.

[16] Attachments 14 & 14-A through 14-N.

## VIII. Fisheries Impacts & Related Mitigation Measures.

### a. The DEIR should disclose that project operations are believed to be a significant contributor to the Pelagic Organism Decline (POD).

The DEIR does not accurately disclose the status of scientific understanding regarding the cause of the Pelagic Organism Decline (POD). For example, at page 7.3-25, the DEIR states:

> POD investigations have proceeded under a *hypothesis* that the recent declines are a response to a new stressor (or at least a new version of an old stressor). The investigation centers around impacts of water project operations, food web changes, and contaminants.

(Emphasis added.)

The impact of the export pumps upon pelagic organisms has evolved beyond mere hypothesis. Subsequent drafts of the EIR should disclose that there is mounting scientific evidence indicating that the export pumps are a major contributing cause to the POD through direct entrainment, habitat modification, and other indirect effects.[17]

### b. Subsequent drafts of the EIR should include the most up-to-date information regarding the POD.

Given the precarious state of the pelagic organisms in the Delta, it is imperative that this EIR attempt to include as much up-to-date information as possible in its analysis of project impacts upon fisheries resources. For example, table 7.3-14, at page 7.3-27, presents the annual results of the adult delta smelt recovery index from 1967 through 2005. This table should be updated to include the 2006 and 2007 results, both of which are now available.[18]

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[17] Attachment 15, F. Feyrer, M. Nobriga & T. Sommer, Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA, Can. J. Fish. Aquat. Sci. 64: 723-734 (2007); Attachment 16, N. Monsen, J. Cloern, J. Burau, Effects of Flow Diversions on Water Habitat Quality: Examples from California's Highly Manipulated Sacramento-San Joaquin Delta (July 2007); The Bay Institute, et al., 2007, *supra*, at p. 21-32.

[18] Attachment 31, California Department of Fish and Game, Fall Midwater Trawl Survey Results (2005-2007), available at "http://www.delta.dfg.ca.gov/data/mwt/."

**c. Subsequent drafts of the EIR should acknowledge that observable take of delta smelt at the pumps represents a tiny fraction of actual take.**

The only quantitative analyses of the project's impacts upon delta smelt contained within the DEIR proceeds by first identifying periods of time during which the project increased pumping at Banks and then examining whether delta smelt take was measured at the pumps during those periods of time. This approach is flawed on many levels.

First, observed incidental take of delta smelt at the state and federal water export facilities is a gross underestimate of the actual number of delta smelt entrained (i.e., killed) at the pumps. The daily take numbers utilized in the DEIR's analysis are calculated by periodically sampling water that is diverted away from the pump intakes by a set of louvers and/or fish screens. Fish that are above 20 mm in length are then counted as having been "taken" during the sampling period. The total "take" for a period of time is then extrapolated from that sampled take. For several reasons, this calculated "take" is not representative of the actual take of delta smelt. First, the louvers and/or fish screens are known to be highly inefficient in their ability to divert smelt away from the pumps (as compared to other, larger fish species). It is estimated that the louvers and/or fish screens miss more than half of the delta smelt that are caught up in the pumping process. Second, delta smelt larvae and juveniles are too small to be counted. Nevertheless, larval and juvenile entrainment is estimated to reach several million individuals each year. Finally, it is not known how many smelt that are drawn near to the pumping facilities are lost to predation and/or other factors and never reach the counting facility.[19]

**d. Subsequent drafts of the EIR should explain why the document considers project-related contributions to certain salvage events to be "negligible."**

In project-related smelt take events # 2 and #3, described at page 7.3-51, the DEIR concludes that the project resulted in negligible contributions to salvage. Yet, it is not clearly explained why the DEIR reaches these conclusions. For example, in event #3, the project contributed a small amount to a month-and-a-half-long continuous salvage event. Although the daily contribution of the project may be relatively small, the project's cumulative contribution to the take event is arguably considerable. The EIR should explain why it concludes otherwise.

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[19] Attachment 17, M. Bowen, et al., Empirical and experimental analyses of secondary louver efficiency at the Tracy Fish Collection Facility, March 1996 to November 1997, Tracy Fish Facility Studies, Volume 11, U.S. Bureau of Reclamation, Mid-Pacific Region, Denver Technical Service Center (2004); Attachment 18, U.S. Fish & Wildlife Service, 5-Year Review, *Hypomesus transpacificus* (delta smelt), Sacramento Fish and Wildlife Office, Sacramento, CA (2004); *see also* The Bay Institute, et al., 2007, *supra*.

**e. Subsequent drafts of the EIR should evaluate the indirect impacts of project operations.**

As discussed above, the analysis of how the increased pumping caused by the project will impact fisheries is confined to an examination of a handful of specific "events" during which project-related pumping coincided with measured smelt and splittail salvage at the pumps. No effort was made to estimate, either qualitatively or quantitatively, the other, indirect impacts exports have on fish species, such as impacts to habitat, water quality, etc.

**f. Subsequent drafts of the EIR should more closely evaluate project impacts upon salmonids passing through the Delta.**

The DEIR, in section 7.3-5, which purports to discuss the effect of the project on special-status fish species in the Sacramento-San Joaquin Delta due to Delta export changes, makes no effort to either qualitatively or quantitatively estimate the impact of the project's operations on migrating salmonids. This is a particularly glaring omission, given that the section concludes at page 7.3-52, that project-related changes in Delta flow patterns could "disrupt movement of species of fish, and increase entrainment losses of adult delta smelt and salmonid smolts."

The DEIR has a responsibility to address the reality that recent salmonid returns, representing the first few post-project salmonid populations to return from the ocean, are at record low population levels.[20] A draft report recently prepared for the CALFED Independent Science Board concludes that increased transit time through the Delta is connected with increased mortality of out-migrating Chinook salmon.[21]

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[20] Attachment 19, California Department of Fish and Game (CDFG) 2007. Excel spreadsheet summary of Chinook salmon escapement for Central Valley Streams, "Grandtab", August 22, 2007 revision. Prepared by the Native Anadromous Fish and Watershed Branch, California Department of the Fish and Game; Attachment 20, John Willams Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California, San Francisco Estuary & Watershed Science, Vol. 4, Issue 3, Art. 2 (2006).

[21] Attachment 33, J. Burau, et al., Sacramento/San Joaquin River Delta Regional Salmon Outmigration Study Plan: Developing Understanding For Management And Restoration (December 10, 2007), Draft Prepared for January 8, 2007 Meeting of the CALFED Independent Science Board.

**g. The DEIR's conclusion that environmental programs in place from 1996 through 2003 were sufficient to render project impacts less-than-significant is unsupportable.**

Despite having concluded that project-related pumping increases from November through March "could change Delta flow patterns, disrupt movement of species of fish, and increase entrainment losses of adult delta smelt and salmonid smolts" (DEIR at 7.3-52), the DEIR concludes that various other programs and agreements are sufficient to have prevented species impacts from 1996 through 2003:

> The department believes that the environmental agreements developed with CDFG prior to and during the 1996-2003 timeframe were sufficient to protect Delta species from the impacts of pumping and satisfy any statutory requirements (see Mitigation Measures section below). In addition, the Banks pumping curtailments to address federal ESA concerns in 1996 (71,000 AF May 16-24), 1997 (10,000 AF June 7-11), 1999 (292,000 AF May 20-June 30), and 2000 (28,000 AF May 25-31) provided some added fish benefits. Beginning in 2000, the EWA Program provided real-time adaptive management response to fish distribution, abundance, and salvage in the Delta.

(DEIR at 7.3-52.)

This ignores the well-documented ecological crisis in the delta, which has worsened in recent years at least in part because of export pumping. (See, e.g., the Adult Delta Smelt Recovery Index, at Table 7.3-14.) The specific programs listed in the DEIR at page 7.3-52 - 7.3-53 are demonstrably not doing enough to sustain Delta species.

**h. It is improper for the DEIR to rely so heavily on existing and planned programs designed to comply with Endangered Species Act requirements.**

The DEIR justifies its finding of less-than-significant impact on special status species in the Sacramento San-Joaquin Delta in part because of the existence of several biological opinions issued under the federal Endangered Species Act to provide incidental take coverage for CVP and SWP facilities. Reliance upon these biological opinions is fundamentally misplaced for several reasons.

First, the DEIR should acknowledge that the district court in *NRDC v. Kempthorne* held that the central pillar around which the most recent delta smelt biological opinion is constructed, an adaptive management program known as the Delta Smelt Risk Assessment Matrix (DSRAM), is unlawful as currently designed.

> The existing DSRAM process provides absolutely no certainty that any needed smelt protection actions will be taken at any time by DSWG or WOMT. The DSRAM is in substance an organizational flow chart that

> prescribes that certain administrative processes (meetings) will be held whenever a trigger criteria is met or exceeded. Although mitigation measures are identified, no defined mitigation goals are required, nor is any time for implementation prescribed. Incorporating some ascertainable mitigation standards and enforceable mitigation measures is not inconsistent with avoiding unduly restrictive "hard-wiring" of the DSRAM. ***
>
> Here, the adaptive management process has no quantified objectives or required mitigation measures. Although the process must be implemented by holding meetings and making recommendations, nothing requires that any actions ever be taken. The BiOp asks the court to trust the agency to protect the species and its habitat. Notwithstanding any required deference to expertise, the ESA requires more. All parties agree that adaptive management can be beneficial and that flexibility is a necessary incident of adaptive management. The law requires that a balance be struck between the dual needs of flexibility and certainty. The DSRAM, as currently structured, does not provide the required reasonable certainty to assure appropriate and necessary mitigation measures will be implemented. The DSRAM does not provide reasonable assurance admitted adverse impacts of the 2004 OCAP will be mitigated.

(*NRDC v. Kempthorne*, Summary Judgment Decision at 57-58.)

More generally, even if the ESA-related programs listed in the DEIR brought the projects into full compliance with the ESA, this would not necessarily satisfy DWR's mandate under CEQA to mitigate significant environmental impacts whenever feasible.

**i. The proposed mitigation measure of implementing an EWA-type program is insufficient.**

The DEIR concludes at page 7.3-71 that future implementation of the project has the potential to "have an adverse impact on Delta fish species by increasing salvage at the Skinner facility as a result of higher pumping at Banks during certain periods when San Luis Reservoir would otherwise be full. This impact is potentially significant."

However, the DEIR then reasons that implementation of an EWA-type program as mitigation will render any such impacts less-than-significant:

> Implementation of the following mitigation measure in combination with the [enumerated] environmental programs already in place or forthcoming that are relevant to the SWP would reduce this impact to a less than significant level.
>
> > The Department shall implement operational assets that could be deployed through a continuation of the EWA, through an

> equivalent type for program, or through another program that would replace the EWA and provide the fish protection required by the court and the Biological pinions on delta smelt and Chinook salmon that would limit any adverse impact resulting from the proposed project on special status Delta fish species as a result of higher pumping at Banks during periods when San Luis Reservoir, absent of the proposed project, would be full.

(DEIR at 7.3-73 - 7.3-74)

As discussed above, the EWA is a failed program that has not lived up to its initial mandate. To merely promise to "implement" an EWA-like program is no better than the status quo. For this to be a useful mitigation measure, DWR must ensure that there are sufficient operational assets to undertake fish protection actions whenever they are recommended. This should become a condition of implementation of the project.

## IX. Chapter 7.16 - Energy.

### a. The DEIR's choice of a 10% significance threshold is not justified.

The SWP is the largest single user of energy in California, using 2-3 percent of all electricity consumed in the state.[22] Why, then, given the enormity of the SWP's impact on California's energy consumption, is the threshold of significance set at 10%. No rationale is provided for setting the threshold at 10%. This threshold seems arbitrarily high, given the overall load the SWP places on the power grid. For example, according to Table 7.16-2 on page 7.16-8, the net load of the project under 2020 conditions will be 102 GWh annually. Assuming, as the CEC does, that California's per capita energy consumption will remain relatively flat for the foreseeable future, at approximately 7,032 Kwh per person per year, the project will cause the use of enough additional energy each year to serve the needs of more than 14,500 individuals.[23]

### b. The analysis used to evaluate the net energy load of the project is not clearly explained.

Table 7.16-2 on page 7.16-8 purports to disclose net energy load and generation for the "Monterey Plus EIR Alternatives." First, despite its title, it does not evaluate Monterey Plus EIR Alternatives at all. Rather, it appears to compare net energy loads under 2020 conditions with and without Monterey. Second, no explanation is given as to why there

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[22] Attachment 21, Ronnie Cohen, Barry Nelson, & Gary Wolff, Energy Down the Drain: The Hidden Costs of California's Water Supply (August 2004), at p. 2, available at: http://www.nrdc.org/water/conservation/edrain/contents.asp.

[23] Attachment 22, California Energy Commission, U.S. Per Capita Electricity Use By State in 2005, http://www.energy.ca.gov/electricity/ us_per_capita_electricity_2005.html (last visited Jan 10, 2008).

are three different time periods analyzed (1922-93, 1929-34, and 1987-92), all of which overlap. This analysis must be more fully explained.

## X. Chapter 11 - Growth Inducing Impacts.

### a. The DEIR should not bury the results of the population growth analysis behind outdated, and misleading figures.

Section 8.2.2, at page 9-8 reveals the shocking truth that the project-related Table A transfers along with Article 21 deliveries could support between 405,103 and 561,684 new residents in the service areas that receive these project-related water deliveries. Yet, this crucially important result is preceded in the document by the recitation, without any hint of its invalidity, of the outdated population growth estimates produced in the original, 1995 Monterey EIR, which predicted that the additional water could support an additional population of 39,000. That data should be removed or clearly marked as erroneous.

### b. The DEIR disregards DWR's responsibility to analyze growth-inducing environmental impacts.

The entirety of DEIR's analysis of the growth-inducing environmental impacts of the project is confined to three paragraphs on the bottom of page 8-11. (The remainder is dedicated to determining the growth that will be induced by the project and/or explaining why these growth estimates are "conservative.")

In essence, although the DEIR admits that the transfers may induce regional population growth on the order of 400,000 -500,000 new residents, the DIER capitulates that "[t]he specific environmental effects associated with increased population are too speculative to predict or evaluate since the exact location and manner of potential future development within the eight M&I contractors' services areas cannot be determined." (DEIR at p. 8-11.)

The DEIR makes no effort to quantitatively or qualitatively review or aggregate some of the known environmental impacts that have and are being caused by these transfers. This is a total derogation of DWR's responsibility to evaluate the statewide impacts of the project. Instead, the local agencies are left to perform piecemeal the analysis, exactly the problem that programmatic environmental analysis is meant to avoid.

The information needed to complete such an analysis is readily available. (In fact, DWR purports to have compiled and reviewed most of this evidence already as part of its "survey" of planning documents.)[24] The following table lists a number of projects in Los Angeles County that depend in large part on Table A transfers made possible by the Monterey Amendments (this may not be an exhaustive list).

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[24] We request that DWR incorporate these surveys into future versions of the EIR.

| Project | General Description |
|---|---|
| West Creek Project | 2,545 units |
| River Valley Project | 1,444 units & 1.5 million square feet of mixed non-residential space |
| Riverpark Project | 1,183 units |
| Northlake Project | 3,000 units |
| Synergy Project | 946 units |
| Mission Village Project | 5,331 units & 1.229 million square feet mixed use commercial space |
| Soledad Townhouse Project | 437 units |
| Lyons Canyon Ranch Project | 190 units |
| Gate-King Annexation, Addendum | 4.45 million square feet of industrial/ commercial space |
| Tick Canyon | 492 units |
| Newhall Ranch | 21,000 units |

Attached to this letter are portions of several of the EIRs for these projects (the impact summary tables from the executive summaries of these documents, along with the water supply sections).[25] The water supply impact sections discuss the extent to which each project relies upon imported, project-related Table A transfers, while the executive summary discloses the wide range of environmental impacts that are anticipated to result from implementation of the proposed projects. The complete EIRs for the projects listed above are easily located and could be utilized to construct a more complete evaluation of the statewide growth-inducing impacts of the project.

**c. DWR cannot allow other agencies to determine whether transfers will be growth inducing.**

By allowing other agencies to determine whether transferred Table A entitlements will be growth-inducing, DWR is relinquishing its responsibility to evaluate the growth-inducing impacts of the project. At the very least, DWR should set a standard for determining

[25] Attachments 23A through 23F: Attachment 23-A, City of Santa Clarita Department of Planning & Building Services, Riverpark Draft Environmental Impact Report (Mar. 2004), Excerpts; Attachment 23-B, City of Santa Clarita, Soledad Village Draft Environmental Impact Report (Nov. 2005), Excerpts; Attachment 23-C, City of Santa Clarita, Gate-King Industrial Park Final Environmental Impact Report (June 2003), Excerpts; Attachment 23-D, City of Santa Clarita, Gate-King Industrial Park Additional Analysis (May 2006); Attachment 23-E, City of Santa Clarita, The Keystone Project Draft Environmental Impact Report (July 2005), Excerpts; Attachment 23-F, Castaic Lake Water Agency, Supplemental Water Project Transfer of 41,000 Acre-Feet of State Water Project Table A Amount, Draft Environmental Impact Report (June 2004), Excerpts.

whether a use is growth inducing and then independently evaluate the uses to which the Table A transfers are being put.

**d. DWR erroneously classifies use of supply to meet "planned population growth and development objectives" as non-growth inducing.**

In one specific instance, DWR has mis-characterized a transfer as non-growth inducing because the transferred water will be used to "meet planned population growth and development objectives specified in their respective General Plans." (See Table 8-1, at p. 8-5, first column, regarding a 5,756 AF transfer of SWP entitlement to the Solano County WA.) Just because a county has previously planned for population growth and development as part of its General Plan does not mean that the county would be able to serve those new residences with existing resources. Moreover, even if water could be acquired from other sources, the environmental impacts of doing so must be evaluated at some point. DWR cannot relinquish its responsibility to evaluate the growth-inducing impacts of the project on this ground.

**e. The DEIR provides inappropriate explanations as to why the estimated growth-inducing impacts are "conservative, over-estimate[s]."**

Section 8.3.2 at page 8-13, suggests that M&I contractors would have gotten water from elsewhere to support growth. This may be true, but acquisition of water from alternative sources would be subject to CEQA review, just as acquisition via the Monterey Agreement transfers is subject to CEQA review here. The possibility that local agencies might have acquired water through other channels does not excuse DWR in any way from performing required environmental analyses of the impacts caused by the transfers that did indeed occur and that are presently being relied upon to support growth (see above).

Nor is it valid for the DEIR to excuse itself from completing a thorough analysis of growth-inducing impacts because local governments are "responsible for considering the environmental effects of their decisions." (DEIR at p. 8-14.) This undermines the purpose of programmatic environmental review, which is to allow for the up-front assessment and mitigation of program-wide impacts, rather than permitting the piecemeal assessment and mitigation of localized portions of such impacts.

## XI. <u>Reliability of Water Supplies and Growth.</u>

**a. Subsequent drafts of the EIR should formally incorporate the Reliability Report, allowing for public input and judicial review of the document relied upon by the DEIR to "resolve" the paper water problem.**

Section 4.5.1 sets fort the requirement that DWR prepare a report every two years describing the reliability of SWP water deliveries under a range of hydrologic conditions.

This report, the Reliability Report, is relied upon by DWR throughout the DEIR to explain why there is no longer a paper water problem. It is, therefore, in a sense, a form of mitigation. Yet, the report itself is not subject to public oversight**,** nor is it a legally enforceable constraint, as would be the case for a true mitigation measure. Accordingly, it would seem appropriate to incorporate the Reliability Report into the DEIR itself, subjecting it to the scrutiny of the CEQA process. Public (and possibly judicial) scrutiny of the Reliability Report is critical, given the extent and nature of the Report's potential shortcomings.[26]

**b. The DEIR erroneously concludes that there is no longer a "paper water" problem.**

Chapter 9 of the DEIR essentially concludes that there is no longer a "paper water" problem because local planners now recognize that it is important to incorporate limitations on the reliability of the SWP into their planning efforts. The analysis in this section is flawed for a number of reasons.

First, DEIR makes no effort to truly address the issues at hand. Historically, land use decisions in California have routinely been made in the absence of reasoned assessments of water supply availability. This problem was so widespread that it resulted in the passage of SB 610 and SB 221. The pre-Monterey contracts contained important mechanisms designed to counteract this problem (Articles 18(b) and 21(g)(1)). If the project is approved as currently described, an important tool that could be used to combat this problem will be lost.

Second, the notion that SB 610 and SB 221 somehow magically eliminate the paper water problem because they require local water agencies to evaluate water supply reliability is ludicrous. The agencies that are subject to those laws routinely look to the state for guidance in determining the reliability of their water supply. With the elimination of Article 21(g)(1), which allows surplus water to be utilized to support permanent developments, DWR has simply created a new type of "paper water" by allowing local decisionmakers the freedom to choose when and how to allow Article 21 water to support permanent developments.

## XII. Cumulative Impact Analysis

The cumulative impacts analysis is lacking for the same reasons articulated elsewhere in this comment letter:

- At page 10.1-13, the Sacramento Valley Water Management Agreement is described but the DEIR does not disclose the connection between the

[26] *See, e.g.*, Attachment 24, Comments of California State Senator Michael J. Machado on the SWP Reliability Report, Oct. 30, 2002; Attachment 25, DWR's Responses to Machado Letter, March 11, 2003.

Agreement's plans to replace surface water supplies with groundwater pumping so that those surface water supplies can be utilized by the SWP.

- Also at page 10.1-13, the DEIR discusses the EWA, and concludes that it is likely that an EWA-like program will continue to be implemented in the future. However, the DEIR again makes no mention of the problems that have arisen as a result of underfunding the EWA.

- At page 10.1-22, the DEIR admits that the cumulative effect of the project in conjunction with other water development projects could potentially affect special status fish species. The DEIR then concludes that various environmental programs along with the implementation of a planned EWA-type program would limit the project's contribution rendering the projects' cumulative impacts less-than significant. The same arguments articulated above at Part VII(g)-(h) apply here.

## XIII. Alternatives Analysis.

### a. The DEIR misstates DWR's responsibility to analyze alternatives.

At page 11-2, the DEIR states that "...the approach taken with the Monterey Plus EIR was to first analyze the environmental effects of the proposed project and determine whether the proposed project had any significant adverse environmental impacts. If the proposed project had no significant adverse environmental effects there would be no need to analyze alternatives other than the required no project alternative." This is not what CEQA requires. Rather, every EIR must analyze a reasonable range of alternatives. As is discussed below, the DEIR fails to comply with this requirement. Remedying this failure should begin with a careful re-statement of DWR's responsibilities regarding alternative analysis.

### b. The DEIR unjustifiably rejects numerous alternatives on the ground that they do satisfy most of the stated objectives of the project.

As described in Chapter 4, the stated specific objectives of the Monterey Amendments are to:

- Resolve conflicts and disputes among SWP contractors regarding water allocations and financial responsibilities for SWP operations;

- Restructure and clarify procedures for SWP water allocation and delivery during times of shortage and surplus;

- Reduce financial pressures on agricultural contractors in times of drought and supply reductions;

- Adjust the financial rate structure of the SWP to more closely match revenue needs;

- Facilitate water management practices and water transfers that improve reliability and flexibility of SWP water supplies in conjunction with local supplies;

- Resolve legal and institutional issues related to storage of SWP water in Kern County groundwater basins and in other areas.

The DEIR unjustifiably eliminates from analysis a number of alternatives on the ground that they do not meet most of the objectives of the project. Several alternatives are eliminated on this basis without any explanation as to why they do not meet the project's objectives. For example, the "No Urban Preference and Dry Year Reliability" alternative is summarily rejected because it would not meet most, if any of the objectives of the project. Yet, it appears that such an alternative would resolve many of the disputes between the parties and satisfy other objectives of the project if implemented correctly. (The other basis given for rejecting this alternative -- that it would "introduce a new level of water management by the state" -- is discussed below.)

Similarly, the rejection of the "Improved Reliability through Environmental Enhancement Alternative" because it would "not meet any of the objectives of the Monterey Amendment" is baseless. Such an alternative could, in fact, meet all of the objectives of the project by enhancing the ability of the SWP to deliver water reliably by restoring the ecosystem services that make water delivery possible and by lessening the need to constrain water operations to protect those ecosystem services.

**c. The document treats as an underlying purpose of the project increased deliveries and exports from the Delta, thereby providing improper justification of the elimination of alternatives that would provide for reduced exports.**

The analysis appears to assume that an objective of the project is to maintain or increase current exports from the Delta. The DEIR eliminates from consideration alternatives that seek to reduce exports without providing any legitimate reason why such an alternative should not be seriously considered. If maintaining or reducing exports is an objective of the project, it should be so stated; if it is not, then DWR has no basis for refusing to analyze a reduced export alternative.

**d. It is not appropriate to reject alternatives simply because they exceed the current authority of DWR.**

Several alternatives were rejected at the screening stage because they would have required changes to DWR's role vis-a-vis local water agencies and land user planners and/or would require actions outside the current scope of DWR's authority. For example, section 11.2.4 discusses the alternative of having DWR "reduce[] stress on fishery

resources in the Delta by directly implementing water use efficiency measures, water recycling, storm water capture and other local water system enhancements that stabilize water demand and improve SWP reliability." (DEIR at p. 11-5.) This alternative was rejected in part because "[t]he Monterey Amendment is not an appropriate tool for mandating 'local water enhancements.' There are other forums where these concerns can be discussed as part of a comprehensive process." (*Id.*) This is an arbitrary distinction. Nothing precludes DWR from evaluating an alternative of this nature. In fact, there some authority that suggests analysis of just such an alternative is required.[27]

Nor should such an alternative be rejected as infeasible. As the Appellate Court made clear in *In re Bay-Delta Programmatic Environmental Impact Report Coordinated Proceedings* (Cal. App. 3 Dist., 2005) 34 Cal.Rptr.3d 696, 774:

> The feasibility of [] a reduced exports alternative is clear, notwithstanding the projected population growth that undergirds the commitment not to reduce exports. As stated previously, it is projected that the state's population will grow from 30 to 49 million by the year 2020, and that half of this growth will be in Southern California. Such population growth requires water. However, if there is no water to support the growth, will it occur as projected? Population growth is not an immutable fact of life. Stable populations have been established in such states as New York, Pennsylvania, Connecticut, and Rhode Island. (Carle, supra, at p. 196.) Inflow of new residents to California continues to exceed outflow because conditions in the State are conducive to population growth. One aspect of these conditions is the availability of water. However, as the State reaches the limit of available water and must seek other sources such as desalination, water will become more expensive to obtain and California's appeal will lessen.

Finally, the DEIR asserts that the environmental review of this project is not the appropriate forum for mandating local water supply enhancements, efficiency measures, or other mechanisms to reduce demand. Yet, there is no guarantee that any of the alternative fora will produce results, let alone results sufficient to mitigate the impacts of this project.

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[27] *See, e.g.*, *In re Bay-Delta Programmatic Environmental Impact Report Coordinated* proceedings (Cal. App. 3d Dist., 2005) 34 Cal.Rptr.3d 696, 773-75; *Friends of the Eel River v. Sonoma County Water Agency* (1st Dist. 2003) 108 Cal App. 4th 859, 864-67, 872-73l (where it seemed likely that FERC would force reductions in Eel River diversion, water agency's EIR for project to increase diversions from the Russian River should have discussed alternatives that would have reduced dependence on diversions from the Eel); *Methow Valley Citizens Council v. Regional Forester* (9th Cir. 1987) 833 F2d 810, 815 (NEPA case which held that even if an alternative requires legislative action, this fact does not necessarily justify excluding that alternative from an EIS).

**e. The alternatives analysis does not provide enough information to allow a meaningful comparison between the alternatives and the project.**

The actual analysis of the environmental impacts of the alternatives vis-a-vis the project is confined to slightly more than a single page of text and a single summary table. Given the extraordinary importance of this project and the emphasis placed on alternatives analysis in *PCL v. DWR*, this analysis is insufficiently detailed, precluding a meaningful comparison between the project and the various alternatives.

## XIV. The DEIR's Treatment of Climate Change is Insufficient.

**a. The Final EIR should include a thorough analysis of the greenhouse gas emissions increases that will result from the particular type of growth supported by the project.**

In light of the passage of AB 32 in September 2006, it is imperative that the final EIR more thoroughly analyze the extent to which the proposed project will result in additional greenhouse gas emissions caused by the additional urban sprawl fueled by various aspects of the project. The Attorney General has openly called for such analyses to be included in CEQA documents.[28]

The DEIR at page 12-14 reminds the reader that in Chapter 8, the DEIR concludes that "the proposed project may result in changes in growth patters at the local level, but would have no effect on statewide population growth." The DEIR then goes on to conclude that "[t]hus, within the SWP service area as a whole, the proposed project would not result in any changes in GHG emission due to growth." This logical leap is unsupportable. The Table A transfers have supported discrete development projects outside existing urban boundaries. The DEIR essentially asserts that location of growth bears no relationship to greenhouse gas (GHG) emissions. This is simply false. The nature and patterns of growth can significantly increase overall GHG emissions of a given population.[29]

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[28] Attachment 26, Letter from Attorney General Bill Lockyer to the County of San Bernardino, dated Oct. 23, 2006; Attachment 31, Office of the California Attorney General, Global Warming Mitigation Measures,

[29] Attachment 27, Reid Ewing, et al., Smart Growth America, Growing Cooler: The Evidence on Urban Development and Climate Change, available at "http://www.smartgrowthamerica.org/gcindex.html" (2007).

**b. The DEIR's analysis of climate change impacts on SWP deliveries is insufficient.**

The DEIR, at pages 12-12 - 12-13, provides a general discussion of how DWR has evaluated the impacts of Climate Change on SWP operations and then summarizes a CalSim II simulation designed to estimate whether there would be a relative difference in the impact of climate change with and without the project. Table 12-2, which presents the results of this analysis, indicates that there would be little or no relative difference. However, this analysis does not explore whether there would be a relative difference in impacts upon M&I contractors versus agricultural contractors. For example, if climate change does indeed reduce SWP supplies by approximately 25% in critical years, this would presumably impact urban contractors much more severely in the absence of Article 18(a) than if that "urban shortage" provision remained in the contracts. These distinct analyses must be included in the final EIR in order to disclose to the public the full impact of the project in light of anticipated climate changes.

**c. The EIR should disclose that, by eliminating Article 18(b), the project is giving up a tool that would enable the SWP to better respond to climate change in the future.**

By eliminating Article 18(b), the project is eliminating a key safeguard that allows DWR to respond to permanent shortages by proportionally and without compensation to the contractors adjusting entitlements to reflect reality. Instead of maintaining or exercising this provision, the project relies instead on its Reliability Report to share information with water agencies about the project's reliability. These two options are not equivalent. The differences between the capacity of Article 18(b) to adjust project operations in light of climate change versus the capacity of the Reliability Report to do the same needs to be analyzed and disclosed.

**d. Climate Change should be incorporated into the analyses contained within the rest of the DEIR.**

Enough is known about climate change to facilitate the incorporation of climate change impacts into the environmental and water supply analyses set forth in the DEIR. It is, in fact, far more likely than not that California's hydrology will be altered as a result of climate change.[30] To ignore this mounting evidence in favor of modeling based on the status quo endangers both the `environment and water supply reliability.

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[30] Attachment 28, N. Miller, California Climate Change, Hydrologic response, and Flood Forecasting, Earth Sciences Division, Berkeley National Laboratory, Berkeley, California, USA. Presented at the International Expert Meeting on Urban Flood Management, November 20-21, 2003, April 30, 2004 (available at: www.osti.gov/bridge/servlets/purl/820274-R49cYy/native/820274.pdf); Attachment 29, Field, C.B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. Climate Change 2007: Impacts,

**e. Alternatives that provide for greater water use efficiency, conservation, reuse, recycling, and reduced exports from the Delta have the potential to lessen the GHG impacts of the project.**

Energy savings is one of the most significant advantages of utilizing water conservation/efficiency measures to achieve greater water supply reliability.[31] The Attorney General of California has identified the implementation of water conservation and efficiency measures as a potential form of mitigation that may be considered under CEQA to offset or reduce the global warming impacts of a project.[32] This should be incorporated into the alternative analysis in subsequent drafts.

## XV. The DEIR Does Not Adequately Disclose or Analyze Kern Water Bank Issues and Impacts.

In general, although the DEIR does include some brief references to the Kern Water Bank within the body of the EIR along with a study of the "Transfer, Development, and Operation of the Kern Water Bank" in Appendix E, the disclosures and analyses contained in the DEIR and its appendices are inadequate to satisfy DWR's requirements under CEQA.

**a. The DEIR does not disclose that transfer of the Kern Fan Element from DWR to the Kern Water Bank Authority via the Kern County Water Agency would alter the fundamental purpose of the water bank.**

Section 4.4.3 (at pp. 4-6 - 4-7) describes the transfer of the Kern Fan Element (KFE) property simply as a transfer of the KFE property and its fixtures to another entity. This obscures the underlying nature of the shift from public to quasi-private control. When the project was controlled by DWR, the "primary purpose of the Kern Water Bank [was] to augment the dependable water supply of the State Water Project."[33] In contrast, the

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Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

[31] *See* Energy Down the Drain, *supra* note 22.

[32] Attachment 32, Office of the Attorney General of California, Global Warming Mitigation Measures, dated Dec. 3, 2007, available at: "http://ag.ca.gov/ globalwarming/ceqa.php."

[33] Attachment 2, Memorandum of Understanding Between the Department of Water Resources of the State of California and Kern County Water Agency for Developing and Operating the Kern Water Bank, March 25, 1987, at p. 2.

March 1995 Statement of Principles for the Kern Water Bank declares that the "primary purpose" of the bank is to "augment water supplies for KWB participants." (DEIR Appendix E, at p. 14.)[34]

**b. Neither the DEIR nor any document associated with the KWB transfer explains how the transfer complies with Water Code § 11464.**

DWR's original purchase of the Kern Fan Element property was only permitted to occur if "the Department's right to use the area for project purposes will be preserved." In addition, "[c]onsistent with section 11464 of the Water Code, the Department shall not sell facilities acquired for the Kern Water Bank."

Water Code Section 11464 provides:

> No water right, reservoir, conduit, or facility for the generation, production, transmission, or distribution of electric power, acquired by the department shall ever be sold, granted, or conveyed by the department so that the department thereby is divested of the title to and ownership of it.

Given that the entire transfer arrangement seems at odds with this legal constraint, the public is entitled to an explanation of DWR's rationale for permitting it to move forward.

**c. Subsequent drafts should clearly disclose that previous environmental analyses of the Kern Water Bank indicated that its operation might have a detrimental impact on the Delta.**

In the first paragraph of section 4.4.3, the DEIR briefly recounts the history of the KFE property. However, it does not disclose that DWR's own environmental analyses prior to the transfer indicated that the bank might have an impact on the Delta.[35] In fact, the Kern Water Bank's own web page asserts that one of the "legal, institutional, and political impediments to implementation of a groundwater storage facility" by DWR was that "proposed revisions of Delta water quality standards and measures to protect threatened and endangered species, [might] affect the SWP's ability to pump water from the Delta for recharge at KWB."[36]

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[34] We request that DWR attach to any subsequent drafts the March 1995 Statement of Principles, the October 1995 Joint Powers Agreement, and any other relevant documents

[35] Attachment 3, DWR, First Stage Kern Fan Element Draft Supplemental Environmental Impact Report (1990), at p. 38-42.

[36] Attachment 4, Kern Water Bank Authority, "DWR & the KWB," available at "http://www.kwb.org" (last visited Jan 1, 2008).

**d. Subsequent drafts should address the assertions made in Public Citizen's report "Water Heist."**

There is no question that the transfer of the Kern Fan Element is a subject of considerable public controversy. An often-cited report by Public Citizen[37] asserts that the KWBA is effectively controlled by a single corporate entity and largely serves the interest of that entity. The report also asserts that the operation of the bank has been and will continue to be environmentally detrimental. DWR should endeavor to address these concerns in subsequent drafts of the EIR.

**e. The analyses of the environmental impacts of the Kern Water Bank in the DEIR and its Appendices are inadequate.**

The DEIR fails to analyze the potentially significant environmental consequences of the transfer and operation of the Kern Water Bank. These potential environmental consequences include the following:

- Increased Delta Exports - As described above, DWR's own pre-transfer environmental documents acknowledge that operation of the bank could increase pressure on the Delta. Other documents previously brought to DWR's attention by the Planning and Conservation League (PCL) document the potential for the bank to impact the Delta.

- Environmental Impacts Resulting from Loss of Public Control - Under the control of a private entity, there can be no assurance that the bank will be utilized to lessen pressures on the Delta during times of shortage, a purpose to which the bank's water could have been directed prior to the transfer. Rather, it can be assumed that the bank will be used as an economic resource for the benefit of its participants. Among the possible implications are increased uses of banked water to support permanent economies, such as housing and permanent crops, each of which would have resulting environmental impacts. In addition, DEIR reveals that the Kern Water Bank made numerous sales to the Environmental Water Account. (DEIR, Appendix E. at 25.) Had the bank remained under state control, it is possible that the state would not have had to purchase EWA water on those occasions from contractors. All of these possible impacts must be evaluated.

The analysis contained within Appendix E barely does not sufficiently explore these questions. Of particular concern is the fact that the "independent" report relies heavily on personal communications with KWBA and KCWA staff, none of whom have trust responsibilities over state water resources.

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[37] Attachment 5, Public Citizen, Water Heist: How Corporations Are Cashing In on California's Water (2003), available at "http://www.citizen.org/california/water/heist."

In sum, we believe that the DEIR contains a number of fundamental flaws that mask the environmental impacts of the project. Moreover, the document fails to place the project into the real-world context of a crashing Delta ecosystem and predicted climate changes. The final EIR must more faithfully disclose the downsides of this project so that the public and relevant decision-makers have an opportunity to steer the SWP in a more rational direction.

For your convenience, with a few exceptions noted on the appended list, we have provided both a hard copy and an electronic copy (on CD-ROM) of each of our attachments.

Thank you for your attention to these comments. We appreciate your hard work and look forward to receiving your responses. Should you have any questions or require clarification, please do not hesitate to contact the undersigned.

Sincerely,

Lisa Coffman, Executive Director
California Water Impact Network

Bill Jennings, Executive Director
California Sportfishing Protection Alliance

**Index of Attachments -**
**C-WIN et al. Comment Letter Re: Monterey Plus DEIR**

(Unless otherwise noted, attachments have also been provided in electronic form.)

1. DWR, The State Water Project Delivery Reliability Report 2005 (2006).

2. Memorandum of Understanding Between the Department of Water Resources of the State of California and Kern County Water Agency for Developing and Operating the Kern Water Bank, March 25, 1987.

3. DWR, First Stage Kern Fan Element Draft Supplemental Environmental Impact Report (1990).

4. Kern Water Bank Authority, "DWR & the KWB," available at "http://www.kwb.org" (last visited Jan. 1, 2008).

5. Public Citizen, Water Heist: How Corporations Are Cashing In on California's Water (2003), available at "http://www.citizen.org/california/water/heist/".

6. J. Payne & D. Purkey, An Environmental Review of CalSim-II: Defining "Full Environmental Compliance" and "Environmentally Preferred" Formulations of the CalSim-II Model" (November 2005).

7. *NRDC v. Kempthorne*, 1:05-cv-1207 (EDCA), Doc. 560, Interim Remedial Order Following Summary Judgment and Evidentiary Hearing, dated Dec. 14, 2007.

8. *NRDC v. Kempthorne*, Doc. 323, Order Granting In Part and Denying In part Plaintiffs' Motion for Summary Judgment, dated May 25, 2007.

9. Matt Weiser, Delta Water Exports Halved, SacBee.com, Dec. 29, 2007.

10. *NRDC v. Kempthorne*, Doc. 398, Declaration of J. Leahigh, dated July 9, 2007.

11. MWDSC, Update on Monterey Amendment, PowerPoint Presentation to the Water Planning and Stewardship Committee, Agenda Item 6(e), presented Jan. 7, 2008, dated Jan. 8, 2008.

12. The Bay Institute, et al., Petition to the State of California Fish and Game Commission and Supporting Information for Listing the Delta Smelt (*Hypomesus transpacificus*) as an Endangered Species under the California Endangered Species Act (Feb. 7, 2007).

13. Environmental Defense, "Finding the Water: New Water Supply Opportunities to Revive the San Francisco Bay Delta Ecosystem" (2005).

14. NRDC, December 10, 2007 Letter to the Bureau of Reclamation Re: Comments on the Draft Supplemental EIS/EIR for Extending the Environmental Water Account and OCAP Consultations.

    14-A. NRDC Letter Exhibit 2 - Teir 3 Protocol.

    14-B. NRDC Letter Exhibit 3 - DSWG Briefing Statement (May 15, 2007).

    14-C. NRDC Letter Exhibit 4 - Statement Presented by Ryan Broddrick, Director, CDFG, to House Subcommittee on Water and power (July 2, 2007).

    14-D. NRDC Letter Exhibit 5 - May, June, July 2007 delta smelt take tables.

    14-E. NRDC Letter Exhibit 6 - Data Assessment Team call notes (Feb. 1, 2005).

    14-F. NRDC Letter Exhibit 7 - CVO smelt report (Feb. 2005).

    14-G. NRDC Letter Exhibit 8 - DSWG notes (July 10, 2007).

    14-H. NRDC Letter Exhibit 9 - DSWG notes for (Dec. 11, 2006).

    14-I. NRDC Letter Exhibit 10 - DSWG notes for (Oct. 10, 2006).

    14-J. NRDC Letter Exhibit 11 - Declaration of Bruce Oppenheim in *NRDC v. Kempthorne* (June 15, 2007).

    14-K. NRDC Letter Exhibit 12 - Declaration of Ronald Milligan in NRDC v. Kempthorne (June 21 2007).

    14-L NRDC Letter Exhibit 13 - Transcript of Hearing re: Interim Remedies Day 7, *NRDC v. Kempthorne*, Testimony of Ronald Milligan at 1553-54 (Aug. 31, 2007).

    14-M. NRDC Letter Exhibit 14 - Declaration of Kirk Rodgers (Oct. 18, 2006); Declaration of Kirk Rodgers (July 9, 2007).

    14-N. NRDC Letter Exhibit 15 - Interagency Ecological Program 2006-2007 Work Plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary (Jan. 12, 2007).

15. F. Feyrer, M. Nobriga & T. Sommer, Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA, Can. J. Fish. Aquat. Sci. 64: 723-734 (2007).

16. N. Monsen, J. Cloern, J. Burau, Effects of Flow Diversions on Water Habitat Quality: Examples from California's Highly Manipulated Sacramento-San Joaquin Delta (July 2007).

17. M. Bowen, et al., Empirical and experimental analyses of secondary louver efficiency at the Tracy Fish Collection Facility, March 1996 to November 1997, Tracy Fish Facility Studies, Volume 11, U.S. Bureau of Reclamation, Mid-Pacific Region, Denver Technical Service Center (2004).

18. U.S. Fish & Wildlife Service, 5-Year Review, *Hypomesus transpacificus* (delta smelt), Sacramento Fish and Wildlife Office, Sacramento, CA (2004).

19. California Department of Fish and Game (CDFG) 2007. Excel spreadsheet summary of Chinook salmon escapement for Central Valley Streams, "Grandtab," August 22, 2007 revision. Prepared by the Native Anadromous Fish and Watershed Branch, California Department of the Fish and Game.

20. J. Willams, Central Valley Salmon: A Perspective on Chinook and Steelhead in the Central Valley of California, San Francisco Estuary & Watershed Science, Vol. 4, Issue 3, Art. 2 (2006).

21. R. Cohen, B. Nelson, & G. Wolff, Energy Down the Drain: The Hidden Costs of California's Water Supply (August 2004).

22. California Energy Commission, U.S. Per Capita Electricity Use By State in 2005, available at "http://www.energy.ca.gov/electricity/ us_per_capita_electricity_2005.html" (last visited Jan 10, 2008).

23-A. City of Santa Clarita Department of Planning & Building Services, Riverpark Draft Environmental Impact Report (Mar. 2004), Excerpts.

23-B. City of Santa Clarita, Soledad Village Draft Environmental Impact Report (Nov. 2005), Excerpts.

23-C. City of Santa Clarita, Gate-King Industrial Park Final Environmental Impact Report (June 2003), Excerpts.

23-D. City of Santa Clarita, Gate-King Industrial Park Additional Analysis (May 2006).

23-E. City of Santa Clarita, The Keystone Project Draft Environmental Impact Report (July 2005), Excerpts.

23-F. Castaic Lake Water Agency, Supplemental Water Project Transfer of 41,000 Acre-Feet of State Water Project Table A Amount, Draft Environmental Impact Report (June 2004), Excerpts.

24. Comments of California State Senator Michael J. Machado on the SWP Reliability Report, dated Oct. 30, 2002.

25. DWR's Responses to Machado Letter, dated Mar. 11, 2003.

26. Letter from Attorney General Bill Lockyer to the County of San Bernardino, dated Oct. 23, 2006.

27. Reid Ewing, et al., Smart Growth America, Growing Cooler: The Evidence on Urban Development and Climate Change, available at "http://www.smartgrowthamerica.org/gcindex.html" (2007).

28. N. Miller, California Climate Change, Hydrologic response, and Flood Forecasting, Earth Sciences Division, Berkeley National Laboratory, Berkeley, California, USA. Presented at the International Expert Meeting on Urban Flood Management, November 20-21, 2003, April 30, 2004, available at: "http://www.osti.gov/bridge/servlets/purl/820274-R49cYy/native/820274.pdf" (last visited Jan. 8, 2007).

29. Field, C.B., L.D. Mortsch, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

30. SWP Initial Requests (100%) 1989-2000. (Provided in hard copy only.)

31. California Department of Fish and Game, Fall Midwater Trawl Survey Results (2005-2007), available at "http://www.delta.dfg.ca.gov/data/mwt/."

32. Office of the Attorney General of California, Global Warming Mitigation Measures, dated Dec. 3, 2007, available at: "http://ag.ca.gov/ globalwarming/ceqa.php."

33. J. Burau, et al., Sacramento/San Joaquin River Delta Regional Salmon Outmigration Study Plan: Developing Understanding For Management And Restoration (December 10, 2007), Draft Prepared for January 8, 2007 Meeting of the CALFED Independent Science Board

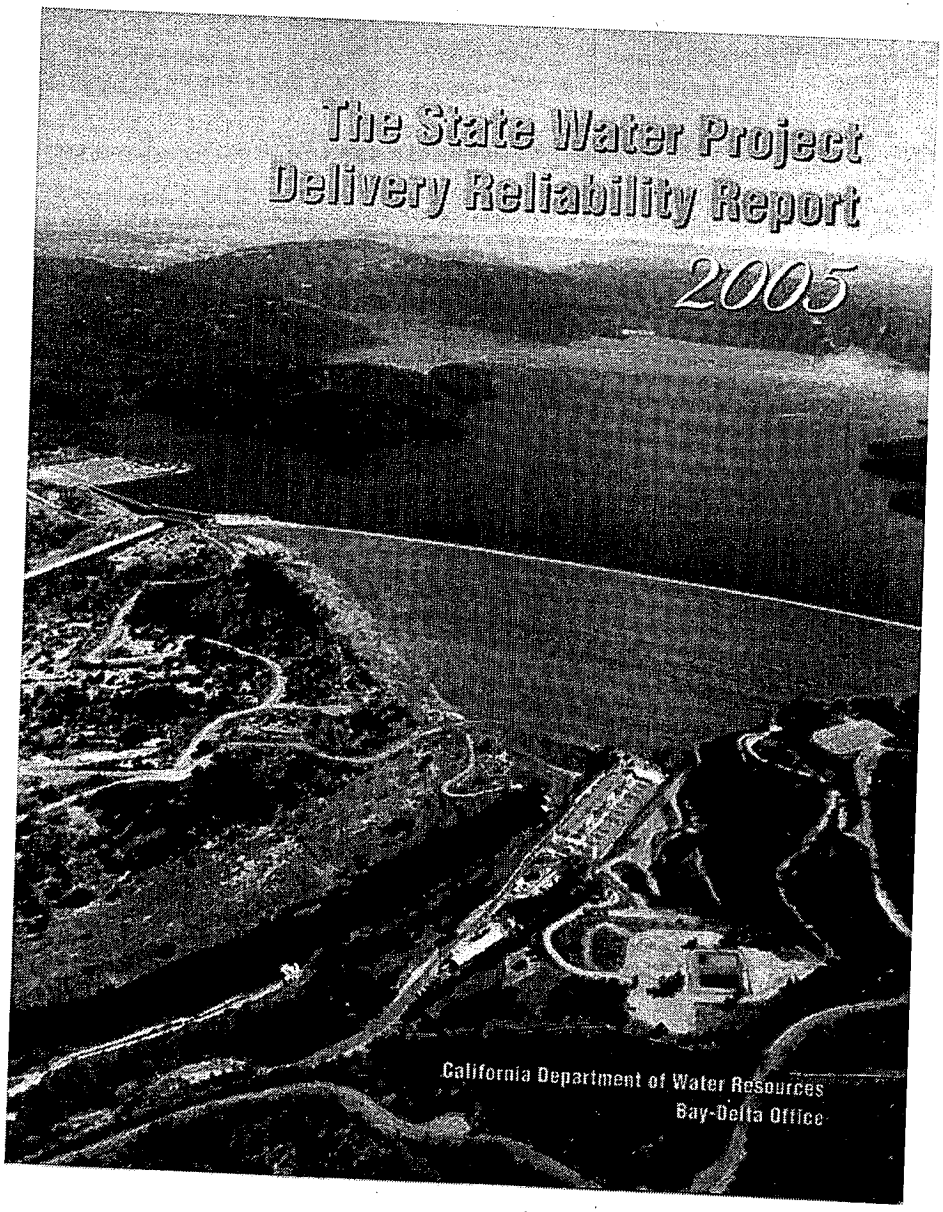
**Electronic Exhibits (provided electronically only).**

EA-A. Spreadsheet: SWP Deliveries, 1980-1999.
EA-B. Spreadsheet: SWP Deliveries, 2000-2007.
EA-C. Spreadsheet: SWP Initial Requests for Selected Contractors 2001.

EA-D. Spreadsheet: SWP Initial Requests for Selected Contractors 2002.
EA-E. Spreadsheet: SWP Initial Requests for Selected Contractors 2003.
EA-F. Spreadsheet: SWP Initial Requests for Selected Contractors 2004.
EA-G. Spreadsheet: SWP Initial Requests for Selected Contractors 2005.
EA-H. Spreadsheet: SWP Initial Requests for Selected Contractors 2006.
EA-I. Spreadsheet: SWP Initial Requests for Selected Contractors 2007.
EA-J. Spreadsheet: SWP Initial Requests for Selected Contractors 2008.

# Attachment 1

# The State Water Project Delivery Reliability Report 2005



California Department of Water Resources
Bay-Delta Office

State of California
The Resources Agency
Department of Water Resources

# The State Water Project Delivery Reliability Report 2005

## Final

April 2006


**Arnold Schwarzenegger**
Governor
State of California

**Mike Chrisman**
Secretary for Resources
The Resources Agency

**Lester A. Snow**
Director
Department of Water Resources


If you need this report in alternate format, call the Office of Workforce Equality at (916) 653-6952 or TDD (916) 653-6934.

# Foreword

The Department of Water Resources (DWR) is issuing this report to update information presented in the first report of this series, *The State Water Project Delivery Reliability Report 2002*, which was finalized in 2003 after an extensive public review. A draft of the *The State Water Project Delivery Reliability Report 2005* underwent a 30-day public review during November and December 2005. The information contained in this update was recommended by DWR in May 2005 for use by SWP water supply contractors in developing their 2005 Urban Water Management Plans.

*The SWP Delivery Reliability Report 2002* and *The SWP Delivery Reliability Report 2005* are based upon analyses using a computer simulation model, CalSim II. Public criticism of this analytical approach centers on two areas: the ability of CalSim II to simulate "real world" conditions and accurately estimate SWP deliveries; and the inability of the approach to account for future uncertainties such as changes in the climate pattern or levee failure in the Delta due to flooding or an earthquake. While no model is perfect, DWR is satisfied with the degree to which CalSim II simulates actual, real-world operations of the SWP. When professional judgment is used with the knowledge of the limitations of CalSim II and the assumptions used in the studies, CalSim II is a useful tool in assessing the delivery reliability of the SWP. The studies and peer review related to CalSim II are discussed in Chapter 3 and Appendix E of this update.

Although the estimates contained in *The SWP Delivery Reliability Report 2005* are the best quantifications available of the delivery ability of the SWP, these estimates are limited because of the uncertainty of future conditions. DWR will continue to use the CalSim II model and its updates as appropriate for analyses, but other information is being developed that will help us analyze, understand, and prepare for our uncertain future. Per the Governor's directive (Executive Order S-3-05), the potential impacts of climate change on the State's resources, including water supply, are being evaluated. Using CalSim II, preliminary estimates have been done of the potential impact upon the SWP 50 to 100 years in the future if no additional conveyance facilities or upstream reservoirs are built. As these estimates become more refined, they will be helpful in guiding strategies for the management and development of the State's water resources, including improvements to the SWP.

In addition, DWR is working on three projects that will improve our ability to make qualitative or quantitative statements about the reliability of conveyance across the Sacramento-San Joaquin Delta. These include: the Delta Risk Management Strategy, which will assess risks to the Delta from floods, seepage, subsidence, and earthquakes, evaluate the consequences of levee failure, and develop recommendations to manage the risk; implementation of AB 1200 (Laird, 2005) which calls for a similar evaluation of impacts on water supplies from catastrophic Delta failure; and a broader public process to develop a shared vision of a sustainable Delta that continues to support societal needs related to water supply, transportation, recreation, land use, energy, and environmental health. Although none of these efforts will be completed before release of the next Reliability Report, some preliminary results and conclusions may be completed. Subsequent Reliability Reports will fully incorporate this information.

The updated SWP delivery estimates are summarized in Chapter 5. Chapter 6 contains examples of how to incorporate this information into a local water supply assessment. These examples are based upon examples contained in the *Draft Guidelines for Documentation and Integration of SWP Supplies with UWMPs*, which will soon be released by DWR for public review. These draft guidelines are designed to assist SWP urban contractors in estimating the amount of SWP supplies available to them and in integrating the SWP supply information with information from other sources of supply to develop an overall assessment of each contractor's total water portfolio. For additional information on the *Draft Guidelines*, contact the Office of Water Use Efficiency and Transfers at (916) 651-7027. DWR's Bay-Delta Office may be contacted at (916) 653-1099 with questions about other aspects of *The SWP Delivery Reliability Report 2005*.

Lester A. Snow
Director
California Department of Water Resources

# Contents

**Chapter 1. Introduction** ..... 1
Purpose ..... 1
Background ..... 2

**Chapter 2. Water Delivery Reliability** ..... 3
What is Water Delivery Reliability? ..... 3
What Factors Determine Water Delivery Reliability? ..... 3
How is Water Delivery Reliability Determined? ..... 3

**Chapter 3. Study Approach and CalSim II Follow-up Studies** ..... 7
Science Program Peer Review of CalSim II ..... 7
The Ability of CalSim II to Estimate Water Deliveries ..... 8
CalSim II Sensitivity Analysis Study ..... 9
Impact of Model Simulation Time-step in Estimating Projects Average Deliveries ..... 10

**Chapter 4. Computer Simulation Assumptions** ..... 13

**Chapter 5. Study Results** ..... 15
Article 21 Deliveries ..... 15
SWP Water Deliveries under Different Hydrologic Scenarios ..... 16
SWP Table A Delivery Probability ..... 19
Potential Adjustments to 1977 CalSim II Table A Deliveries ..... 22
Additional Analysis of Tables B-3 through B-7 in Appendix B ..... 22

**Chapter 6. Examples of How to Apply Information** ..... 23
Example 1 ..... 23
Example 2 ..... 25

**Appendix A. 2005 Delivery Reliability Report CalSim II Modeling Assumptions** ..... A-1

**Appendix B. Results of Report Studies** ..... B-1

**Appendix C. State Water Project Table A Amounts** ..... C-1

**Appendix D. Recent State Water Project Deliveries** ..... D-1

**Appendix E. Technical Memorandum Report Summaries: Historical SWP/CVP Operations Simulation and CalSim II Model Sensitivity Analysis** ..... E-1

**Appendix F. Guidelines for Review of Proposed Permanent Transfers of SWP Annual Table A Amounts** ..... F1

**Appendix G. Comment Letters on the Draft Report and the Department's Responses** ..... G-1



## Figures

Figure 3-1 SWP south-of-Delta Table A deliveries (1987-1992 dry period) ..... 10
Figure 5-1 SWP Delta Table A delivery probability for year 2005 ..... 21
Figure 5-2 SWP Delta Table A delivery probability for year 2025 ..... 21
Figure B-1 SWP Delta Table A delivery probability for studies 1, 2 and 3 ..... B-9
Figure B-2 SWP Delta Table A delivery probability for studies 4 and 5 ..... B-9

## Tables

Table 4-1 Key study assumptions ..... 13
Table 5-1 SWP Table A demand from the Delta ..... 16
Table 5-2 SWP Table A delivery from the Delta ..... 17
Table 5-3 SWP Article 21 demand and delivery from the Delta (taf per year except as noted) ..... 18
Table 5-4 SWP average and dry year Table A delivery from the Delta ..... 18
Table 5-5 Average and dry year delivery under Article 21 (taf per year) ..... 19
Table 5-6 SWP average and wet year Table A delivery from Delta ..... 20
Table 5-7 Average and wet year delivery under Article 21 (taf per year) ..... 20
Table 6-1 SWP average and dry year Table A delivery from the Delta in five-year intervals for studies 4 and 5 ..... 25
Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions ..... A-3
Table A-2 2001 American River Demand Assumptions ..... A-12
Table A-3 2020 American River Demand Assumptions ..... A-13
Table B-1 Key study assumptions ..... B-2
Table B-2 SWP average and dry year Table A delivery from the Delta for studies 4 and 5 ..... B-2
Table B-3 SWP water delivery from the Delta for Study 1 (taf) ..... B-4
Table B-4 SWP Water Delivery from the Delta for Study 2 (taf) ..... B-5
Table B-5 SWP Water Delivery from the Delta for Study 3 (taf) ..... B-6
Table B-6 SWP water delivery from the Delta for Study 4 (taf) ..... B-7
Table B-7 SWP water delivery from the Delta for Study 5 (taf) ..... B-8
Table C-1 Maximum Annual SWP Table A Amounts ..... A-2
Table D-1 Historical State Water Project Deliveries: 1995 ..... 2
Table D-2 Historical State Water Project Deliveries: 1996 ..... 3
Table D-3 Historical State Water Project Deliveries: 1997 ..... 4
Table D-4 Historical State Water Project Deliveries: 1998 ..... 5
Table D-5 Historical State Water Project Deliveries: 1999 ..... 6
Table D-6 Historical State Water Project Deliveries: 2000 ..... 7
Table D-7 Historical State Water Project Deliveries: 2001 ..... 8
Table D-8 Historical State Water Project Deliveries: 2002 ..... 9
Table D-9 Historical State Water Project Deliveries: 2003 ..... 10
Table D-10 Historical State Water Project Deliveries: 2004 ..... 11
Table E-1 Summary excerpt of Elasticity Index (EI) and Sensitivity Index (SI) for selected variables from Table 2 ..... E-5

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# Chapter 1. Introduction

Will there be enough water? Public officials throughout California face this question with increasing frequency as growth and competing uses strain existing resources. Water supply, however, has always been an uncertain and contentious matter in our state. For many years, the Department of Water Resources (DWR) has investigated this question. At its simplest level, the question might be, "How many wells are needed for a rural town's water supply?" or "How many people can a 100,000 acre-foot reservoir serve?" But for most areas of the state, the evaluation of water supply adequacy is not simple. The answer requires a complex analysis, taking into account multiple sources of water, a range of water demands, the timing of water uses, hydrology, available facilities, regulatory restraints, levels of demand management (water conservation) strategies, and, of course, future weather patterns.

Most water users in California live in areas that rely on multiple sources of water supply, some local and some imported. Typically, local water providers "mix and match" their supply sources to maximize water supply and quality and to minimize cost. In addition to considering available sources of supply, local water providers are planning for ways to improve the efficiency of local water uses and the operation of their water management systems. To help with this effort, DWR presents 25 different resource management strategies available to local agencies and governments and private utilities in the *California Water Plan Update 2005* (see website at http://www.waterplan.water.ca.gov).

## Purpose

*The State Water Project Delivery Reliability Report 2005* presents DWR's current information regarding the annual water delivery reliability of the State Water Project (SWP) for existing and future levels of development in the water source areas, assuming historical patterns of precipitation. This report first looks at the general subject of water delivery reliability and then discusses how DWR determines delivery reliability for the SWP. A discussion of the analysis tool (the CalSim II computer simulation model), the analyses, and peer review regarding the accuracy of CalSim II and its suitability for use in this report is included. Finally, estimates of SWP delivery reliability today and in the future are provided along with examples of how to incorporate this information into local water management plans.

This report responds to a requirement in the settlement agreement[1] with the Planning and Conservation League to provide an assessment of the existing delivery capability of the SWP over a range of hydrologic conditions. The range of conditions is to include the historic extended dry cycle and the long-term average. In addition, the biennial report is to include the total amount of project water delivered and the amount of project water delivered to each contractor for each of the 10 years immediately preceding the report (see Appendix D, Recent SWP Deliveries).

*The State Water Project Delivery Reliability Report 2005* does not include analyses of how specific water agencies should integrate SWP water supply into their water supply equation. That topic requires extensive information about local facilities, local water resources, and local water use, which is beyond the scope of this report. Moreover, such an analysis would require decisions about water supply and use that traditionally have been made at the local level. DWR believes that local officials should continue to fill this role. The examples provided in Chapter 6 are included to help local agencies incorporate the information presented in this report into local water management assessments.

[1] *Planning and Conservation League v. Department of Water Resources* (2000) 83 Cal. App. 4th 892





## Background

The original *SWP Delivery Reliability Report* was issued as a draft in August 2002. In 2002, DWR held six public meetings throughout the state to discuss the report and receive comments upon the content. The final *SWP Delivery Reliability Report* was released in early 2003. *The State Water Project Delivery Reliability Report 2005* is an update to the report issued in 2003. DWR intends to publish biennial updates of the *SWP Delivery Reliability Report* in the future.

The SWP supplies two-thirds of the state's population with a portion of its water supply and provides water to irrigate, in part, 750,000 acres of agriculture. The SWP delivers water under long-term contracts to 29 public water agencies throughout the state. They, in turn, either deliver water to water wholesalers or retailers or deliver it directly to agricultural and urban water users.

The water delivery reliability of the SWP is of direct interest to those who use SWP supplies because it is an important element of the overall water supply in those areas. Local supply reliability is of key importance to local planners and local government officials who are responsible for planning for future growth while assuring that an adequate and affordable water supply is available for the existing population and businesses. This function is usually conducted in the course of preparing a water management plan such as the Urban Water Management Plans required by Water Code section 10610. The information in this report may be used by local agencies in preparing or amending their water management plans and identifying the new facilities or programs that may be necessary to meet future water demands.

Local agencies and governments and private utilities will also find in this report information that is useful in conducting analyses mandated by laws requiring water retailers to demonstrate whether their water supplies are sufficient for certain proposed subdivisions and development projects subject to the California Environmental Quality Act. DWR published the *Guidebook for Implementation of Senate Bill 610 and Senate Bill 221 of 2001*, which includes suggestions on how local water suppliers can integrate supplies from various sources, such as the SWP, into their analyses. DWR has also published the *Guidebook to Assist Water Suppliers in the Preparation of a 2005 Urban Water Management Plan*, which includes suggestions on how local water suppliers can integrate supplies from other sources such as the SWP in their analyses. Both documents can be found on the DWR's Office of Water Use Efficiency home page at http://www.owue.water.ca.gov.

The *Draft Guidelines for Documentation and Integration of SWP Supplies with UWMPs* will soon be released for public review. These guidelines are designed to assist SWP urban contractors in determining the amount of SWP supplies available to them. Using the information in this report (*SWP Delivery Reliability Report 2005*), these guidelines explain how to integrate the SWP supply information with supply information from other sources to develop an overall reliability assessment of each contractor's total water portfolio.

# Chapter 2. Water Delivery Reliability

## What is Water Delivery Reliability?

"Water delivery reliability" means how much one can count on a certain amount of water being delivered to a specific place at a specific time.

Objectively, water delivery reliability indicates a particular amount of water that can be delivered with a certain numeric frequency. A delivery reliability analysis assesses such things as facilities, system operation, water demand, and weather projections.

Subjectively, water delivery reliability indicates an acceptable or desirable level of dependability of water deliveries to the people receiving the water. Usually, a local water agency in coordination with the public it serves determines the acceptable level of reliability and plans for new facilities, demand-management and conservation programs, or additional water supply sources to meet or maintain this level.

## What Factors Determine Water Delivery Reliability?

In its simplest terms, water delivery reliability depends on three general factors:

1. Availability of water from the source (that is, the natural source or sources of the water from which the supplier draws, such as a particular watercourse or groundwater basin). Availability of water from the source depends on the amount and timing of precipitation and runoff, or "hydrology," which provides water to the stream or groundwater basin, and the anticipated patterns of use and consumption of this water within the source area, including water returned to the source after use.
2. Availability of means of conveyance (that is, the means for conveying the water from the source via pumps, diversion works, reservoirs, canals, etc. to its point of delivery). The ability to convey water from the source depends on the existence and physical capacity of the diversion, storage, and conveyance facilities and also on contractual, statutory, and regulatory limitations on the operation of the facilities.
3. The level and pattern of water demand in the delivery service area (destination). The level of water demand in the delivery service area is affected by the magnitude and types of water demands, level of water conservation strategies, local weather patterns, water costs, and other factors. Supply from a water system may be sufficiently reliable at a low level of demand but become less reliable as the demand increases. In other cases, the reliability of a water supply system to meet a higher demand may be maintained at its past level because new facilities have been added or the operation of the system has been changed.

## How is Water Delivery Reliability Determined?

### Water Delivery Reliability is Defined for a Specific Point in Time

For this report, water delivery reliability is analyzed for 2005 conditions and for conditions projected to exist 20 years in the future (2025). These analyses must describe current conditions adequately and make predictions about the three factors described earlier and discussed here.

*The Availability of Water at the Source*

This factor depends on how much rain and snow there will be in any given year and what the level of development (that is, the use of water) will be in the source areas. No model or analytical tool can predict the actual, natural water supplies for any year or years in the future. Until the impacts of climate change on precipitation and runoff patterns in California are better quantified, future weather patterns are usually assumed to be similar to those in the past,





especially where there is a significant historical rainfall record.

The State Water Project analyses contained in this report are based upon 73 years of historical records (1922-1994) for rainfall and runoff that have been adjusted to reflect the current and future levels of development in the source areas by analyzing land use patterns and projecting future land and water use. These series of data are then used to forecast the amount of water available to the SWP under current and future conditions.

The assumption that past rainfall-runoff patterns will be repeated in the future has an inherent uncertainty, especially given the evolving information on the potential effects of global climate change. The *California Water Plan Update 2005* (December 2005) states:

> California's water systems have been designed and operated based on data from a relatively short hydrologic record. Mounting scientific evidence suggests that forecasted climate changes could significantly change California's precipitation pattern and amount from that shown by the record. Less snowpack would mean less natural water storage. More variability in rainfall, wetter at times and drier at times, would place more stress on the reliability of existing flood management and water systems. California's high dependence on reservoir storage and snowpack for water supply and flood management makes us particularly vulnerable to these types of projected hydrologic changes. (See Chapter 4 in this volume and articles in Volume 4 Reference Guide under Global Climate Change for further discussion.)
> (*California Water Plan Update*, December 2005, Vol. 1, page 3-15)

Potential changes in climate patterns are becoming better defined and attempts to quantify the resulting impacts to SWP water supply are underway. Broad brush estimates are being developed of the potential impact upon the SWP in 50 to 100 years if no additional conveyance facilities or upstream reservoirs are built. As this information becomes more refined, it will be helpful in guiding the development of statewide strategies for the future management and development of water resources facilities, including the SWP.

*The Ability to Convey Water from the Source to the Desired Point of Delivery*

This factor describes the facilities available to capture and convey surface water or groundwater and the institutional limitations placed upon the facilities. The facilities and institutional limitations may be assumed to be those that currently exist. Alternatively, predictions may be made regarding planned new facilities. Assumptions made about the institutional limitations to operation—such as legal, contractual, or regulatory restrictions—often are based upon existing conditions. Future changes in conditions that affect the ability to convey water usually cannot be predicted with certainty, particularly the regulatory and other institutional constraints on water conveyance.

The analyses in this report include the assumptions that current regulatory and institutional limitations regarding water quality, fish protection, and flows will exist 20 years in the future (2025); no facility improvements, expansions, or additions will be made to the SWP; and conveying water through the Sacramento-San Joaquin Delta will not be significantly interrupted.

Most of the Delta's levees do not meet modern engineering standards and are highly susceptible to failure. Levees are subject to failure at any time of the year due to seepage or the piping of water through the levee, slippage or sloughing of levee material, or sudden failure due to an earthquake. DWR is working on three projects that will improve the ability to make qualitative or quantitative statements about the reliability of conveyance across the Sacramento-San Joaquin Delta. These include: the Delta Risk Management Strategy, which will assess risks to the Delta from floods, seepage, subsidence, and earthquakes, evaluate the consequences of levee failure, and develop recommendations to manage the risk; implementation of AB 1200 (Laird, 2005) which calls for a similar evaluation of impacts on water supplies from catastrophic Delta failure; and a broader public process to develop a shared vision of a sustainable Delta that continues to support societal needs related to water supply, transportation, recreation,

land use, energy, and environmental health. Information developed through these efforts will be incorporated into subsequent Reliability Reports.

*The Level of Demand*

This factor includes the amount and pattern of water demand on the water management system. Demand can have a significant effect upon the reliability of a water system. For example, if the demand occurs only three months in the summer, a water system with a sufficient annual supply but insufficient water storage may not be able to reliably meet the demand. If, however, the same total amount of demand is distributed over the year, the system could more easily meet the demand because the need for water storage is reduced.

Demand levels for the SWP are derived from historical data and information received from the SWP contractors. Demand on the SWP is nearing the maximum Table A amount. Each of the SWP contracts has a Table A, which lists the maximum annual delivery amount over the period of the contract. These annual amounts usually increase over time. Most contractors' Table A amounts reached a maximum in 1990. The total of all contractors' maximum Table A amounts is 4.173 million acre-feet (maf) per water year. Table A is used to define each contractor's portion of the available water supply that DWR will allocate and deliver to that contractor. The Table A amounts in any particular contract, accordingly, should not be read as a guarantee of that amount but rather as the tool in an allocation process that defines an individual contractor's "slice of the pie." The size of the "pie" itself is determined by the factors described in this report. (See Appendix C for additional explanation and listing of the maximum Table A amounts.)

There are 29 SWP contractors. Yuba City, Butte County, and the Plumas County Flood Control and Water Conservation District are north of the Delta. Their maximum Table A amounts total 0.040 maf. The maximum Table A amounts for the remaining 26 contractors, which receive their supply from the Delta, total 4.133 maf. This report focuses on SWP deliveries from the Delta because the amount of water pumped from the Delta by SWP facilities is the most significant component of the total amount of SWP deliveries. The results presented in this report regarding the percent of Table A deliveries applies to contractors north of the Delta in the same manner as those contractors receiving supply from the Delta.

**Past Deliveries May Not Accurately Predict Future Deliveries**

It is worthwhile to note that in some situations, actual, historical water deliveries cannot be used with a significant degree of certainty to predict future water deliveries. As discussed earlier, there are continual, significant changes over time in the determinants of water delivery for a specific water supply system: changes in water storage and delivery facilities, in water use in the source areas, in water demand in the receiving areas, and in the regulatory constraints on the operation of facilities for the delivery of water. Given the very significant changes that have occurred for the SWP over the past 40 years, past deliveries are not a good predictor of current deliveries, much less of future deliveries.

For example, the demand 30 years ago for water from the SWP was not as high as it is currently or expected to be in the future. Because the demand for SWP water then was low, less water was transported through the SWP during normal and wet times than could have been if the demand had been higher. Simply put, less water was delivered in those past years because less water was needed. Conversely, the projected deliveries of a water project would be less than the past if the water project had been operated at its maximum ability for many years, no new facilities were planned to be built, and the annual supply from one of its main sources of water was recently reduced and would remain at the reduced level.

**Many Assumptions Must Be Made in the Determination and Analysis of Water Delivery Reliability**

As discussed earlier, to plan for the future, many assumptions must be made about the future. One of the most significant assumptions for water planning in general is how wet, dry and variable the weather will be. For many planning purposes and until the potential effects of climate change are better defined, the assumption is that future patterns of weather will be like the past, and an effort is made to develop information on





the longest historical period for which acceptable records exist.

Using the historical record, planners analyze the worst drought in the period of record to evaluate how the water management systems will respond. Precipitation information for the Central Valley used for this report begins in 1922 and records the area's worst multi-year drought (1928-1934), although the brief drought from 1976 through 1977 was more acutely dry. Whatever assumptions are made, every responsible water delivery reliability analysis should expressly state the assumptions, methods and data used to produce its results. It should be understood that those numbers depend on, and are no better than, the assumptions upon which they must necessarily rest.

Because assumptions are the foundation upon which the estimates are made, it is helpful to know how each assumption affects study results. For example, what impact would a significant increase in water use in the source areas have upon the projected SWP water delivery reliability? Would it significantly reduce the amount of SWP supply, and if so, by how much? These types of questions can be answered by varying specific factors to see the impact upon the results. These studies are referred to as sensitivity analyses and can be helpful in assessing the importance of certain assumptions to the study results. Per a commitment in the 2002 Reliability Report, DWR has conducted a sensitivity analysis for assumptions contained in the CalSim II model studies. The results of this study are discussed in Appendix E. In the future, the results of this study will be analyzed to develop more detailed findings regarding SWP Delta deliveries. Summaries of the findings of other studies of CalSim II, as well as a peer review of the model, are contained in this report and discussed in more detail in Appendix E.

# Chapter 3. Study Approach and CalSim II Follow-up Studies

This report presents information from computer simulation studies of the operation of the SWP using the CalSim II model. CalSim II is a planning model developed by the Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR). It simulates the SWP and the Central Valley Project (CVP) and areas tributary to the Sacramento-San Joaquin Delta. Using historical rainfall and runoff data, which has been adjusted for changes in water and land use that have occurred or may occur in the future, the model simulates the operation of the water resources infrastructure in the Sacramento and San Joaquin river basins on a month-to-month basis. In the model, the reservoirs and pumping facilities of the SWP and CVP are operated to assure the flow and water quality requirements for these systems are met.

The month-to-month simulations are conducted over the 73-year period (1922-1994) of the adjusted historical rainfall/runoff data. This approach incorporates the over-arching assumption that the next 73 years will have the same rainfall/snowmelt amount and pattern, both within-year and from year to year, as the period 1922 through 1994. The studies do not incorporate any modifications to account for changes related to climate patterns or assess the risk of future seismic or flooding events significantly disrupting SWP deliveries. The results of the CalSim II studies conducted for this update to *The State Water Project Delivery Reliability Report 2002* (DWR 2003a) represent the best available assessment of the delivery capability of the SWP.

Since the release of the 2002 report, a peer-review and several studies have been conducted regarding CalSim II. These reports include:

- An external peer review commissioned by the California Bay-Delta Authority (CALFED);
- An analysis of an historical operations simulation;
- An analysis of the effect varying selected parameters has upon model results (sensitivity analysis study); and
- An analysis of the significance of the simulation time-step to the estimated SWP delivery amounts.

An overview of these efforts follows.

## Science Program Peer Review of CalSim II

In 2003, the CALFED Science Program commissioned an external review panel to provide an independent analysis and evaluation of the strengths and weaknesses of CalSim II. The central question put to the review panel was whether the CALFED program had adopted an appropriate approach to modeling the Central Valley Project/State Water Project (CVP/SWP) system. The panel considered a variety of CalSim II issues and addressed how future model development activities could be managed to assure quality results for current and proposed applications. The panel published its results in *A Strategic Review of CALSIM II and its Uses for Water Planning, Management, and Operations in Central California* (Close and others 2003).

In general, the panel concluded that the current modeling approach was comparable to other state-of-the-art models and addressed many of the complexities of the CVP/SWP system. To balance the competing needs of those who require greater detail from the model and those who require less detail, the panel recommended steps to achieve a more comprehensive, modular, and flexible approach in modeling practices and tools. To increase user confidence in model results and to provide a basis for gauging the





model's ability to produce absolute predictive results of system behavior, the panel suggested calibration and verification of the model, as well as analyses in sensitivity and uncertainty.

In what was most relevant to the subject of this report on the SWP delivery reliability, the panel summarized its observation on the accuracy of the model to estimate the delivery capability of both the CVP and SWP systems in the *Strategic Review's* Appendix F "Analysis of the November 2003 CalSim II Validation Report." Appendix F is discussed in the next section.

In August 2004, DWR and the USBR jointly responded to the questions, comments, and recommendations of the review panel in a report, *Peer Review Response: A Report by DWR/Reclamation in Reply to the Peer Review of the CalSim II Model Sponsored by the CALFED Science Program in December 2003.* (*Peer Review Response*). In their report, the agencies outline current and planned work on model development and the priorities for improving CalSim II. The *Peer Review Response* also highlights the ongoing and planned efforts to establish trust in and credibility for the model by improving documentation, conducting sensitivity and uncertainty analyses of the model parameters and results. Other efforts include enhancing the level of detail in the geographic representation of the system, and improving hydrologic input and software development.

Many of the elements of model development outlined in the *Peer Review Response* are in progress and will be implemented in the updated version of the model, CalSim III. Some of the *Strategic Review's* pressing issues regarding the reliability of CalSim II as a planning tool are addressed below.

## The Ability of CalSim II to Estimate Water Deliveries

The accuracy of CalSim II in simulating "real-world" conditions was one of the major issues raised by the peer review panel. The review panel focused on the system's delivery capability as a major concern to water users as well as water managers who rely on CalSim II when making planning decisions. In Appendix F of the *Strategic Review*, the panel expresses concern that CalSim II overestimates deliveries to south-of-Delta water users. This observation is based on comparing the average deliveries for the last 10 years (1993-2002) with the average annual deliveries in a 73-year model simulation (1922-1994) conducted at the 2001 level of development.

In *Peer Review Response*, DWR and USBR (2004) conclude the concern about overestimations of south-of-Delta deliveries is unwarranted because the 73-year study referenced by the panel is not designed to mimic historical conditions; rather it is intended to determine the reliability of the SWP when the demand equals the maximum Delta Table A amount (4.133 maf) every year. The results of the referenced study are documented in *The SWP Delivery Reliability Report 2002* (DWR 2003a) as study 3 (2021B).

A more appropriate method for assessing the ability of CalSim II to accurately model SWP operations is to compare the historical SWP deliveries with the simulated deliveries of the Historical Operations Study. DWR committed to conducting this study in *The SWP Delivery Reliability Report 2002* (DWR 2003a). The study is documented in the November 2003 Technical Memorandum Report *CALSIM-II Simulation of Historical SWP/CVP Operations* (DWR 2003b). The Historical Operations Study is designed to assess the ability of CalSim II to mimic historical operations of the SWP. In this study, historical input is used where reliable data are available. In situations where reliable historical record is not readily available, reasonable assumptions and estimates are made.

Comparing the average annual historical deliveries with the simulated deliveries in the Historical Operations Study for the dry period shows reasonable results: The average annual SWP south-of-Delta Table A delivery for the 6-year drought of 1987-1992 is 1,930 taf per year, compared to 2,030 taf per year for actual historical deliveries (Figure 3-1). Figure 3-1 compares the simulated Table A deliveries with the actual Table A deliveries for calendar years 1987 through 1992. Although the averages are close, the annual differences between the simulated and actual values can be large. This illustrates that the results of CalSim II analyses are best used for estimating SWP performance over longer periods of time and that considerable judgment must be used when analyzing a specific year. Figure 3-1 replaces the figure contained in the draft of this report which showed the calculated annual delivery amounts would be very close to the

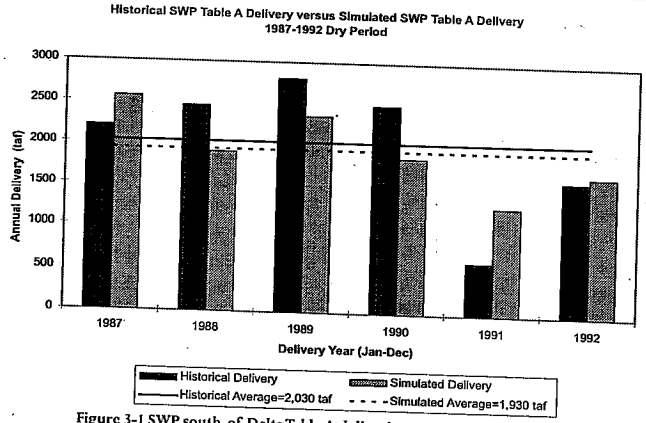


Figure 3-1 SWP south-of-Delta Table A deliveries (1987-1992 dry period)

actual annual delivery amounts, if SWP reservoir storages were adjusted to match the historical values. Additional discussion on this subject is contained in the response to the comment letter from the Planning and Conservation League (Appendix G, Comment Letters on the Draft Report and the Department's Responses).

The observed differences in the annual historical and simulated deliveries can be attributed to differences in the operational rules and parameters assumed in the simulation run. Some of the major operational parameters that could be different between the model run and the actual historical operations include the rule governing the amount of delivery versus the amount of storage to be carried-over into the following year (delivery-carryover storage rule), flood control rules, San Luis Reservoir operation rule, Delta outflow requirements, regulatory decisions, Delta export curtailments caused by pumping facilities outages or compliance with state and federal endangered species regulations, compliance with the provisions of the Coordinated Operations Agreement, implementation of a drought water bank, and water transfers.

In the wetter years (above-normal and wet year-types), when supply is plentiful and deliveries are mostly determined by demands, the simulated deliveries are very close to historical values. When long-term values are compared, the average annual delivery for the SWP during the 23-year period of 1975-1997 is 1,810 taf per year for the Historical Operations Study and 1,790 taf per year for the historical deliveries.

Additional details of this study are in Appendix E.

## CalSim II Sensitivity Analysis Study

The sensitivity analysis is an important component of any water resources planning model evaluation. The sensitivity analysis procedures explore and quantify the impact of possible errors in input data on the model outputs and system performance measures. With a simple sensitivity analysis procedure, errors in model input parameters are generally investigated one at a time. With a more complex procedure, the investigation can be conducted by varying a set of parameters simultaneously. In the sensitivity analysis conducted in response to the recommendations in the *Strategic Review* (Close and others 2003), the simple procedure was adopted and errors in model input parameters were investigated one at a time. The objective of the analysis was twofold: (1) to examine the behavior of the





model in response to variations in selected input parameters; (2) to provide a basis for CalSim II modelers for prioritizing future model development activities. The *CalSim-II Model Sensitivity Analysis* is available at website http://baydeltaoffice.water.ca.gov/index.cfm.

There are many input parameters used in the CalSim II model to define the physical characteristics of the system, as well as the regulatory environment and operational characteristics. Some input parameters are in the form of time series or monthly distribution curves, and others are simply single values. Some input parameters are estimated from the historical data, and others are values developed or calibrated by users. After consultation with model developers and project operators, 21 model input parameters in four major categories with reasonable ranges of variations were selected for this sensitivity analysis study. The results of the sensitivity analysis are given in more detail in Appendix E.

Examination of the results of the sensitivity analysis provides the following information on the behavior of the SWP system's delivery capability with respect to some of the key input parameters:

- The most significant input parameters affecting SWP Table A Delta deliveries are the assumed SWP Table A demands and the monthly Delta diversion limits applied to Banks Pumping Plant. The results show the long-term average annual SWP Table A Delta deliveries between 3.0 maf to 3.5 maf increase by 0.54 acre-foot for every acre-foot increase in Table A demands. The increase is 0.33 acre-foot for every acre-foot of increase in Table A demands for the range between 3.5 maf per year and 3.9 maf per year.
- Also, the long-term average annual SWP Table A Delta deliveries decrease by 0.48 acre-foot for every 1 acre-foot per month decrease in the monthly Delta diversion limits applied to Banks Pumping Plant during the March 16 to December 14 period. This sensitivity study evaluates a 5 percent reduction in the capacity during this period.
- Inflow to Lake Oroville displays a moderate impact on the SWP Table A Delta deliveries. The long-term average annual SWP Table A Delta deliveries increase by 0.20 acre-foot for every acre-foot increase in annual Oroville inflows.
- The effect of changing SWP contractors' demands for Article 21 water on Article 21 deliveries is high, as expected. The results show that for every acre-foot of change in the peak monthly demands for Article 21 water in the range between 134 taf per month and 400 taf per month, the long-term average annual Article 21 deliveries increase by 0.27 acre-foot.

Examples of parameters not significantly influencing the estimates for SWP Delta deliveries include the projected land use in the source areas and inflow into Lake Shasta and Folsom Reservoir.

## Impact of Model Simulation Time-step in Estimating Projects Average Deliveries

In general, the delivery reliability of the SWP is assessed using monthly time-step CalSim II simulations. Monthly time-step simulations implicitly assume that daily hydrologic variability combined with daily physical and regulatory operating constraints are not significant to the forecast of expected average annual deliveries. In other words, it is assumed that a study with monthly inflows, reservoir releases, exports, and associated constraints would produce the same long-term average annual deliveries as a study where inflows, releases, exports, and associated constraints vary on a daily basis.

To confirm the above assumption, results were examined from a recently completed, simplified, daily time-step CalSim II simulation conducted for the California Bay-Delta Authority's Surface Storage Investigations. The assumptions for the baseline monthly and daily time-step simulations are documented in the draft report "Interim Common Model Package, Modeling Protocol and Assumptions" (CALFED 2005). The daily variability appears to have only minor impacts on SWP Table A deliveries. The results show the long-term average annual SWP Table A delivery is increased by 0.3 percent and the average annual deliveries during two 6-year droughts (1929-1934 and 1987-1992) is increased by 0.8 percent in the daily simulation.

## Cited References

CALFED Bay-Delta Program. 2005. Interim Update of the CALFED Bay-Delta Program Surface Storage Investigations: Interim Common Model Package, Modeling Protocol and Assumptions. Technical Memorandum Report. Availability: http://www.storage.water.ca.gov/docs/Interim_Update_Modeling_TM_050405.pdf

Close A., Haneman W.M., Labadie J.W., Loucks D.P. (chair), Lund J.R., McKinney D.C., Stedinger J.R. 2003. A Strategic Review of CalSim II and its Use for Water Planning, Management, and Operations in Central California. Oakland, CA: Submitted to the California Bay Delta Authority Science Program, Association of Bay Governments. 4 Dec. Availability: http://science.calwater.ca.gov/pdf/CalSim_Review.pdf.

[DWR and USBR] California Department of Water Resources, and US Bureau of Reclamation. 2004. Peer Review Response: A Report by DWR/Reclamation in Reply to the Peer Review of the CalSim II Model Sponsored by the CALFED Science Program In December 2003. Jul. Availability: http://baydeltaoffice.water.ca.gov/modeling/hydrology/Peer%20Review%20Response%20(August%202004).pdf.

[DWR] California Department of Water Resources, Bay-Delta Office. 2003a. The State Water Project Delivery Reliability Report 2002. Final.

[DWR] California Department of Water Resources, Bay-Delta Office. 2003b. CalSim II Simulation of Historical SWP-CVP Operations. Technical Memorandum Report. Nov. Availability: http://science.calwater.ca.gov/pdf/CalSimII_Simulation.pdf.

## Additional References

CALFED Bay-Delta Program. 2000. Programmatic Record of Decision.

[DOF] California Department of Finance. 2004. California's Annual Population Growth Exceeds Half a Million For Fifth Year. http://www.dof.ca.gov/HTML/DEMOGRAP/e-1press.doc. May 6 .

[IPCC] Intergovernmental Panel on Climate Change. 2001. The Scientific Basis: IPCC Third Assessment Report. Cambridge, UK: Cambridge University Press.

# Chapter 4. Computer Simulation Assumptions

The selection of the assumptions and factors that go into the estimation of future water delivery reliability is very important and must be tailored to the particular water supplier. Assumptions and factors for the State Water Project focus on Sacramento and San Joaquin river basin precipitation; water rights and uses; SWP storage and conveyance facilities, including diversion facilities in the Delta; SWP service area demand; and the statutes, regulations, and contractual provisions that govern and regulate the SWP, including coordinating operations with the federal Central Valley Project (CVP). A detailed list of the study assumptions for this report is found in Appendix A.

The results of five computer simulations are included in this report. Studies 1, 2, and 3 are from the *The State Water Project Delivery Reliability Report 2002* (DWR 2003). The results of studies 1, 2 and 3 are included in this report for comparison purposes. Studies 4 and 5 are updated studies conducted specifically for this report. A significant difference between the updated studies and the earlier studies is the assumed demands for SWP Table A and Article 21. Article 21 refers to a section of the water supply contracts that allows additional water to be delivered under certain conditions (see Chapter 5 for further discussion).The assumed demands for studies 4 and 5 were developed in discussions with SWP water contractors and stakeholders involved in the development of the analyses associated with the environmental documentation for the Monterey Agreement. The demands developed for studies 4 and 5 are within the range covered under the current SWP biological opinions.

The assumptions for the studies differ in three main categories: the assumed level of water use in the source areas (the level of development), the assumed SWP Table A and Article 21 demands, and the base model assumptions. These categories are summarized in Table 4-1.

Table 4-1 Key study assumptions

| Study | Study name | Level of development (year) | SWP Table A demand (maf/year) | SWP Article 21 demand (taf/month) | Model version |
|---|---|---|---|---|---|
| **SWP Delivery Reliability Report (2003)** | | | | | |
| 1 | 2001 Study | 2001 | 3.0–4.1 | 0–84, Apr–Nov<br>50–134, Dec–Mar | May 2002 benchmark |
| 2 | 2021A Study | 2021 | 3.3–4.1 | 0–84, Apr–Nov<br>50–134, Dec–Mar | May 2002 benchmark |
| 3 | 2021B Study | 2021 | 4.1 | 0–84, Apr–Nov<br>50–134, Dec–Mar | May 2002 benchmark |
| **Updated Studies** | | | | | |
| 4 | 2005 Study | 2005 | 2.3–3.9 | 0–84, Apr–Nov<br>100–184, Dec–Mar | 2004 OCAP |
| 5 | 2025 Study | 2025 | 3.9–4.1 | 0–84, Apr–Nov<br>100–184, Dec–Mar | 2004 OCAP |

maf = million acre-feet

OCAP = 2004 Long-Term Central Valley Project Operations Criteria and Plan

taf = thousand acre-feet





The water use estimates for the source areas for 2001 are assumed to be representative of 2005. The water use estimates for the source areas for 2020 are assumed to be representative of 2021 and 2025 conditions.

The SWP contractors' Table A and Article 21 demands for deliveries from the Delta assumed for the five studies are shown in Table 4-1. In four of the studies, a range in Table A demands is shown because the demand is assumed to vary each year with the weather in the delivery areas. In study 3 (2021), the SWP Table A demand is maximized each year, regardless of weather. Article 21 deliveries are available on an unscheduled and interruptible basis and are not counted as part of the Table A amount. (See Chapter 5 for more discussion of Article 21.) The Article 21 demand in the updated studies (4 and 5) is higher than the earlier studies for the December through March period.

Two versions of the model are used for these studies as shown in Table 4-1. Studies 1, 2 and 3 are based on the May 2002 benchmark study version. The updated studies (4 and 5) use the most recent version, which was developed for the 2004 Long-Term Central Valley Project Operations Criteria and Plan (OCAP). The assumption differences between the May 2002 benchmark version and the 2004 OCAP version that affect the SWP simulation significantly are listed below. A complete list of the differences in key assumptions is included in Appendix A.

1. Addition of a minimum pumping level at Banks Pumping Plant of 300 cubic feet per second.
2. Addition of flow requirements for flow at the mouth of the Feather River for SWP Settlement Contractors.
3. Delivery-carryover relationship adjusted to reduce delivery targets and increase carryover in critically dry years.
4. Addition of Lake Oroville end-of-September carryover target storage rule.
5. Study 5 assumes the implementation of Freeport Regional Water Project, including modified East Bay Municipal Utility District operations on the Mokelumne River.

All studies assume current SWP Delta diversion limits (often referred to as "Banks Pumping Plant capacity"), existing conveyance capacity of the upper Delta-Mendota Canal/California Aqueduct system, and current SWP/CVP operations agreements.

## Cited Reference

[DWR] California Department of Water Resources, Bay-Delta Office. 2003. The State Water Project Delivery Reliability Report 2002. Final.

# Chapter 5. Study Results

The five CalSim II model studies in this report are described in Chapter 4. Studies 1, 2, and 3 are from the *The State Water Project Delivery Reliability Report 2002* (DWR 2003). Studies 4 and 5 are updated studies conducted specifically for this report. The results of studies 1, 2 and 3 are included in this report for comparison purposes. This chapter contains tables summarizing the estimated delivery amounts of the studies for the entire study period (1922-1994), dry years, and wet years and presents information on the estimated probability of SWP delivery amounts currently and twenty years in the future. The annual values for SWP deliveries estimated by CalSim II for the five studies are listed in tables B-3 through B-7 of Appendix B. These tables also show the annual Table A demands assumed for each study.

The results of the updated studies (4 and 5) are compared to the results of the earlier studies (1, 2 and 3) to identify and explain any significant differences in estimated delivery values. For most values, the differences are not large enough to be significant and are generally caused by differences in the assumed demands. There are, however, significant differences between the updated and earlier studies for the estimated deliveries during 1, 2 and 4-year droughts. These differences are discussed further in "Drought Years." Information from studies 4 and 5 was transmitted to SWP contractors (Notice Number 05-08) in May 2005. Studies 4 and 5 are referred to as studies 6 and 7 in the notice.

## Article 21 Deliveries

The studies estimate delivery amounts for Table A and Article 21. As mentioned in Chapter 2, Table A is the contractual method for allocating available supply, and the total of all maximum Table A amounts for deliveries from the Delta is 4.133 million acre-feet (maf) per year. Article 21 refers to a provision in the contracts for delivering water that is available in addition to Table A amounts. (See Appendix C for more detail about Table A and Appendix D for historical delivery amounts.) Article 21 of SWP contracts allows contractors to receive additional water deliveries only under specific conditions. These conditions are:

1. It is available only when it does not interfere with Table A allocations and SWP operations;
2. It is available only when excess water is available in the Delta;
3. It is available only when conveyance capacity is not being used for SWP purposes or scheduled SWP deliveries; and
4. It cannot be stored within the SWP system. In other words, the contractors must be able to use the Article 21 water directly or store it in their own system.

Water supply under Article 21 becomes available only during wet months of the year, generally December through March. Because an SWP contractor must have an immediate use for Article 21 supply or a place to store it outside of the SWP, not all SWP contractors can take advantage of this additional supply.

The importance of Article 21 water to local water supply is tied to how each contractor uses its SWP supply. For those SWP contractors who are able to store their wet weather supplies, Article 21 supply can be stored by being put directly into a reservoir or by offsetting other water that would have been withdrawn from storage, such as local groundwater. In the absence of storage, Article 21 water is not likely to contribute significantly to local water supply reliability. Incorporating supplies received under Article 21 into the assessment of water supply reliability is a local decision based on specific local circumstances, facts, and level of water supply reliability required.





Table 5-1 SWP Table A demand from the Delta

| Study | Average demand | | Maximum demand | | Minimum demand | |
|---|---|---|---|---|---|---|
| | (taf per year) | (percent of maximum Table A) | (taf per year) | (percent of maximum Table A) | (taf per year) | (percent of maximum Table A) |
| **SWP Delivery Reliability Report (2003):** | | | | | | |
| 1. 2001 Study | 3,712 | 90% | 4,114 | 100% | 3,007 | 73% |
| 2. 2021A Study | 4,026 | 97% | 4,133 | 100% | 3,343 | 81% |
| 3. 2021B Study | 4,133 | 100% | 4,133 | 100% | 4,133 | 100% |
| **Updated Studies:** | | | | | | |
| 4. 2005 Study | 3,290 | 80% | 3,862 | 93% | 2,321 | 56% |
| 5. 2025 Study | 4,110 | 99% | 4,133 | 100% | 3,898 | 94% |

Maximum Delta Table A is 4.133 million acre-feet per year

This report presents information on Article 21 water separately, so local agencies can determine whether it is appropriate to incorporate this supply into their analyses.

## SWP Water Deliveries under Different Hydrologic Scenarios

Tables 5-1 and 5-2 summarize the assumed Table A demands for the updated (4 and 5) and the earlier (1, 2, and 3) studies and the resulting estimates for SWP deliveries. Table 5-3 presents information on the assumed Article 21 demand and the estimated Article 21 deliveries. Tables 5-4 through 5-8 summarize values for dry and wet hydrologic periods. The estimated probabilities for a given amount of annual SWP delivery are presented in Figures 5-1 and 5-2.

### Assumed Table A Demands

The average, maximum, and minimum Table A demands from the Delta for the five studies are shown in Table 5-1. Study 4 has lower assumed demands than study 1. The average demand for study 4 is 80 percent of maximum Table A compared to 90 percent of maximum Table A for study 1. The primary reason for the lower demand in study 4 is that it includes a new set of annual Table A demands for the Metropolitan Water District of Southern California (MWDSC) prepared specifically for 2003 conditions by MWDSC. The average demand for study 5 is 99.4 percent of maximum Table A and is very similar to study 3. The annual assumed demand for study 5 is less than maximum Table A in only seven wet years due to the assumption that some Table A deliveries would be replaced by supplies from the Kern River.

As explained in Chapter 2 and Appendix C, the maximum Table A amounts for the 26 contractors which receive their supply from the Delta total 4.133 maf. The demands for studies 1 and 4 assume slightly earlier conditions when the maximum Table A amounts totaled slightly less than 4.133 maf (4.114 maf and 4.112 maf, respectively). To simplify the use of this report, the calculation of demand or delivery in percent of maximum Table A is based on the maximum Delta Table A total of 4.133 maf for all five studies. This simplification has no significant effect on the annual delivery percentages for studies 1 and 4. Additional information can be found in Appendix B.

### Table A and Article 21 Deliveries

Table 5-2 contains the average, maximum, and minimum estimates of Table A deliveries from the Delta for the five studies. Comparing the relevant updated and earlier studies shows the averages of the estimated delivery percentages and the maximum estimated deliveries do not vary significantly. Study 4 has an average delivery of 68 percent of maximum Table A compared to 72 percent for study 1. This lower delivery under current conditions is due to the lower demand level assumed for study 4. The slightly higher average delivery of 77 percent for study 5 compared to 75 percent for study 2 is attributed to the higher demand assumed for study 5 and to differences in modeling assumptions as summarized in Chapter 4 and listed in Appendix A. The average delivery for study 5 is one percentage

Table 5-2 SWP Table A delivery from the Delta

| Study | Average delivery | | Maximum delivery | | Minimum delivery | |
|---|---|---|---|---|---|---|
| | (taf per year) | (percent of maximum Table A) | (taf per year) | (percent of maximum Table A) | (taf per year) | (percent of maximum Table A) |
| **SWP Delivery Reliability Report (2003):** | | | | | | |
| 1. 2001 Study | 2,962 | 72% | 3,845 | 93% | 804 | 19% |
| 2. 2021A Study | 3,083 | 75% | 4,128 | 100% | 830 | 20% |
| 3. 2021B Study | 3,130 | 76% | 4,133 | 100% | 830 | 20% |
| **Updated Studies:** | | | | | | |
| 4. 2005 Study | 2,818 | 68% | 3,848 | 93% | 159 | 4% |
| 5. 2025 Study | 3,178 | 77% | 4,133 | 100% | 187 | 5% |

Maximum Delta Table A is 4.133 million acre-feet per year.

point higher than study 3 even though study 3 has a slightly higher demand. This slightly higher value for study 5 is due to differences in modeling assumptions.

Comparing the updated studies (2005 versus 2025 study levels) shows study 5 has an average delivery of 77 percent of maximum Table A compared to 68 percent for study 4, an increase of 9 percent. This average increase in delivery is due to the higher demand assumed for study 5. Although the average amount (quantity) of delivery is shown to increase over time, the ability of the SWP to meet the assumed demands decreases over time. The responses from the Department to the comments of the Coachella Valley Water District and the Planning and Conservation League in Appendix G discuss this subject in more detail.

The difference between the earlier studies and the updated studies for the estimated minimum Table A delivery is significant. The updated studies have a minimum delivery of 4 percent to 5 percent of maximum Table A compared to 19 to 20 percent for the studies in the *SWP Delivery Reliability Report 2002* (DWR 2003). The lower minimum delivery is primarily due to modification of the delivery-carryover storage rule. Compared to the rule used for the earlier studies, the modified rule reduces delivery by about 80 percent whenever carryover storage (sum of the end-of-September storages of Oroville Reservoir and the SWP share of San Luis Reservoir) is projected to be less than about 860 thousand acre-feet (taf). The modified rule was developed in coordination with the DWR's SWP Operations Control Office to meet the primary objective of reducing the number of years storage in Oroville Reservoir reaches a very low level. The minimum delivery occurs in 1977, the driest year in the 73-year simulation. A closer look at this estimation is done later in this chapter. It applies reasonable assumptions about the amount of Table A deliveries carried-over in San Luis Reservoir from the previous year by SWP contractors and the use of storage in San Luis Reservoir to illustrate how the estimate could be adjusted to 20 percent of maximum Table A while not reducing storage in Oroville Reservoir.

Average Article 21 demands and average, maximum, and minimum Article 21 deliveries for the five studies are shown in Table 5-3. All studies have the same Article 21 demand from April through November. The updated studies (4 and 5) assume a 200 taf increase in Article 21 demand for the period December through March compared to the earlier studies (50 taf per month).

The average Article 21 delivery for study 4 is 260 taf per year, an increase of 130 taf per year from the study 1 average delivery of 130 taf per year. This increase in delivery is a result of the increase in Article 21 demand of 200 taf per year in studies 4 and 5 and also due to the decrease in Table A demand in study 4 compared to study 1. Study 5 has an average Article 21 delivery of 120 taf per year, 40 taf per year more than study 2 and 50 taf per year more than study 3. These increases are the result of the higher assumed Article 21 demand.





Table 5-3 SWP Article 21 demand and delivery from the Delta (taf per year except as noted)

| Study | Average Article 21 demand | | Total | Annual delivery from the Delta | | |
|---|---|---|---|---|---|---|
| | Dec-Mar | Apr-Nov | | Average | Maximum | Minimum |
| **SWP Delivery Reliability Report (2003):** | | | | | | |
| 1. 2001 Study | 504 | 607 | 1,111 | 130 | 510 | 0 |
| 2. 2021A Study | 504 | 607 | 1,111 | 80 | 400 | 0 |
| 3. 2021B Study | 504 | 607 | 1,111 | 70 | 400 | 0 |
| **Updated Studies:** | | | | | | |
| 4. 2005 Study | 704 | 607 | 1,311 | 260 | 1,110 | 0 |
| 5. 2025 Study | 704 | 607 | 1,311 | 120 | 550 | 0 |

Delivery numbers rounded to the nearest 10,000 acre-feet.

Table 5-4 SWP average and dry year Table A delivery from the Delta

| Study | SWP Table A delivery from the Delta (in percent of maximum Table A) | | | | | |
|---|---|---|---|---|---|---|
| | Average 1922-1994 | Single dry year 1977 | 2-year drought 1976-1977 | 4-year drought 1931-1934 | 6-year drought 1987-1992 | 6-year drought 1929-1934 |
| **SWP Delivery Reliability Report (2003):** | | | | | | |
| 1. 2001 Study | 72% | 19% | 48% | 37% | 41% | 40% |
| 2. 2021A Study | 75% | 20% | 44% | 39% | 40% | 41% |
| 3. 2021B Study | 76% | 20% | 44% | 39% | 40% | 41% |
| **Updated Studies:** | | | | | | |
| 4. 2005 Study | 68% | 4% | 41% | 32% | 42% | 37% |
| 5. 2025 Study | 77% | 5% | 40% | 33% | 42% | 38% |

### Drought Years

Table 5-4 includes estimates of water deliveries under an assumed repetition of historical drought periods for the five studies. The years are identified as dry by the Eight River Index, a good indicator of the relative amount of water supply available to the SWP. The Eight River Index is the sum of the unimpaired runoff from the four rivers in the Sacramento Basin used to define water conditions in the basin plus the four rivers in the San Joaquin Basin, which correspondingly define water conditions in that basin. The eight rivers are the Sacramento, Feather, Yuba, American, Stanislaus, Tuolumne, Merced, and San Joaquin. Table 5-4 also includes the average deliveries for comparison purposes.

As discussed earlier in conjunction with the minimum deliveries shown in Table 5-2, the single-year drought deliveries for the updated studies are estimated at 4 percent to 5 percent of maximum Table A compared to 19 to 20 percent for the studies in the *SWP Delivery Reliability Report 2002* (DWR 2003). The 2-year drought average annual delivery decreases from 48 percent for study 1 to 41 percent for study 4. Similarly, study 5 delivery decreases to 40 percent as compared to 44 percent for studies 2 and 3. The results for a 4-year drought show a 5 percent decrease in delivery for study 4 compared to study 1 and a 6 percent decrease in delivery for study 5 compared to studies 2 and 3, for the same reason. The decreases in each of these cases are primarily due to modification of the delivery-carryover storage rule as discussed earlier.

For the updated studies, the annual delivery for the single dry year is estimated to be about the same amount whether the dry year happens now or in twenty years. This is also true for estimated annual deliveries during the multi-year drought periods. This is projected to occur even though the amount of reservoir carryover storage resulting from the increased demand is projected to be less. This result is attributable to the operation rules governing the amount of water that must be retained for carryover storage, the fact the SWP demand between 2005 and 2025

Table 5-5 Average and dry year delivery under Article 21 (taf per year)

| Year | Study 1 | Study 2 | Study 3 | Study 4 | Study 5 |
|---|---|---|---|---|---|
| | 2001 | 2021A | 2021B | 2005 | 2025 |
| 1929 | 0 | 0 | 0 | 0 | 0 |
| 1930 | 90 | 30 | 30 | 120 | 140 |
| 1931 | 0 | 0 | 0 | 0 | 0 |
| 1932 | 200 | 40 | 40 | 240 | 110 |
| 1933 | 130 | 10 | 10 | 510 | 550 |
| 1934 | 0 | 0 | 0 | 210 | 240 |
| 1976 | 110 | 0 | 0 | 190 | 0 |
| 1977 | 0 | 0 | 0 | 0 | 0 |
| 1987 | 0 | 0 | 0 | 550 | 180 |
| 1988 | 0 | 0 | 0 | 0 | 0 |
| 1989 | 0 | 0 | 0 | 0 | 90 |
| 1990 | 0 | 0 | 0 | 0 | 0 |
| 1991 | 0 | 0 | 0 | 0 | 0 |
| 1992 | 0 | 0 | 0 | 0 | 100 |
| 1922-1994 average | 130 | 80 | 70 | 260 | 120 |

Numbers rounded to the nearest 10,000 acre-feet.

increases only slightly, and because less water is made available under Article 21.

Table 5-5 summarizes the estimates of dry year deliveries under Article 21 for the five studies. The updated studies (4 and 5) have higher deliveries than the earlier studies (1, 2 and 3) because of assumed higher Article 21 demand. Also notice the reductions in delivery for studies 2 and 3 compared to study 1 in the years 1930, 1932, 1933, and 1976. These reductions are due to the increase in Table A deliveries. The average values for Article 21 deliveries for Study 5 is lower than study 4, primarily due to the assumed higher Table A demand in study 5.

### Wet Years

Tables 5-6 and 5-7 summarize the model run results for historical wet years. As with drought years, the Eight River Index is used to identify the wet years. Because plenty of water is available for deliveries in wet years, variations in Table A delivery are due to variations in the demand assumed for each of the studies.

Table 5-7 contains information about Article 21 deliveries for the wet period 1978-1987. The information illustrates a significant decrease in the availability of Article 21 supply between study 5 and study 4. This is primarily due to the increase in Table A demand. Article 21 deliveries are generally higher in the updated studies (4 and 5) than the earlier studies (1, 2 and 3). This is attributed to the 200 taf per year increase in Article 21 demand assumed for studies 4 and 5. In addition, the increase in Article 21 deliveries for study 4 compared to the study 1 is partially due to the lower Table A demand assumed for study 4.

## SWP Table A Delivery Probability

The probability that a given level of SWP Table A amount will be delivered from the Delta is shown for the two current condition studies (1 and 4) in Figure 5-1 and for the three future condition studies (2, 3, and 5) in Figure 5-2. The plot lines in the figures are derived from the study results listed in tables B-3 through B-7. Each line is constructed by ranking the 73 annual Table A delivery values of the relevant study from lowest to highest and calculating the percentage of values equal to or greater than the delivery value of interest. For example, for study 4 in Figure 5-1, the value of 3.3 maf is in the 30 percent position of the ranking; therefore,





Table 5-6 SWP average and wet year Table A delivery from Delta

| Study | SWP Table A delivery from the Delta (in percent of maximum Table A) | | | | | |
|---|---|---|---|---|---|---|
| | Average 1922-1994 | Single wet year 1983 | 2-year wet 1982-1983 | 4-year wet 1980-1983 | 6-year wet 1978-1983 | 10-year wet 1978-1987 |
| **SWP Delivery Reliability Report (2003):** | | | | | | |
| 1. 2001 Study | 72% | 73% | 79% | 80% | 80% | 80% |
| 2. 2021A Study | 75% | 82% | 89% | 86% | 87% | 84% |
| 3. 2021B Study | 76% | 100% | 100% | 91% | 91% | 87% |
| **Updated Studies:** | | | | | | |
| 4. 2005 Study | 68% | 60% | 65% | 69% | 75% | 72% |
| 5. 2025 Study | 77% | 95% | 97% | 93% | 93% | 89% |

Table 5-7 Average and wet year delivery under Article 21 (taf per year)

| Year | Study 1 | Study 2 | Study 3 | Study 4 | Study 5 |
|---|---|---|---|---|---|
| | 2001 | 2021A | 2021B | 2005 | 2025 |
| 1978 | 100 | 100 | 100 | 300 | 300 |
| 1979 | 140 | 90 | 100 | 160 | 140 |
| 1980 | 100 | 70 | 80 | 140 | 90 |
| 1981 | 120 | 0 | 0 | 550 | 70 |
| 1982 | 390 | 100 | 60 | 800 | 170 |
| 1983 | 200 | 200 | 160 | 400 | 360 |
| 1984 | 410 | 380 | 370 | 550 | 490 |
| 1985 | 0 | 0 | 0 | 0 | 0 |
| 1986 | 50 | 50 | 60 | 120 | 80 |
| 1987 | 0 | 0 | 0 | 550 | 180 |
| 1922-1994 average | 130 | 80 | 70 | 260 | 120 |

Numbers rounded to the nearest 10,000 acre-feet.

it is equaled or exceeded by 30 percent (about 22) of the 73 delivery values. The delivery value of 0.16 maf, the minimum value for study 4, is equaled or exceeded by all of the delivery values.

The curve for study 4 is generally lower than study 1 due to assumed lower annual demands. Neither curve reaches 100 percent because the assumed annual demands are 100 percent (99.5 percent) of the maximum Delta Table A in only two years for study 1 and the assumed maximum demand for study 4 is 93 percent of the maximum Delta Table A. In study 1, the two years with demand at 100 percent are dry years so delivery of 100 percent is not possible. The divergence of the two curves for the minimum delivery amounts (100 percent probability of being equaled or exceeded) is due to modification of the delivery-carryover storage rule.

Study 5 shows higher deliveries than study 3 for delivery values exceeded by up to 70 percent of the values, and mostly lower deliveries for values exceeded by 80 to 100 percent of the values. Because the assumed demands are nearly the same for these two studies, the delivery differences between study 5 and study 3 are primarily due to modification of the delivery-carryover storage relationship. The delivery-carryover relationship assumed in study 5 allows less delivery than study 3 in dry years which results in higher carryover storage and higher deliveries in normal to above normal years. Study 5 deliveries reach 100 percent 26 percent of the time, the highest percentage for the five studies.

The amount of SWP Table A delivery per year, either in percent of maximum Delta Table A or in thousand acre-feet, associated with a

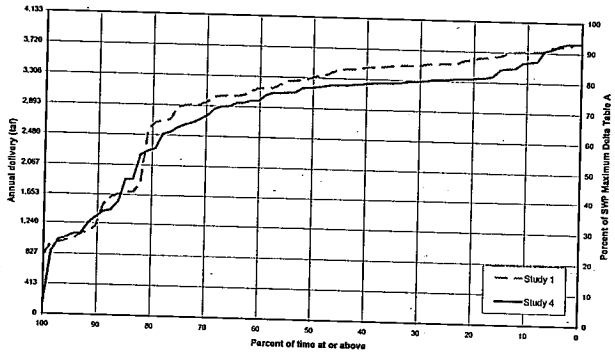


Figure 5-1 SWP Delta Table A delivery probability for year 2005

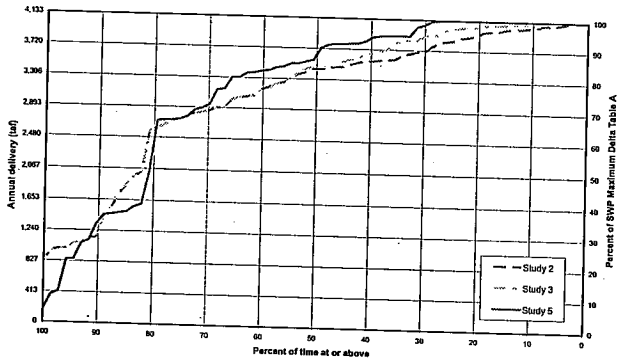


Figure 5-2 SWP Delta Table A delivery probability for year 2025

specific degree of reliability can be estimated from Figures 5-1 and 5-2 for 2005 and 2025 conditions, respectively. The study 4 curve in Figure 5-1 is recommended to be used to represent 2005 conditions, and the study 5 curve in Figure 5-2 is recommended to be used to represent 2025 conditions. By referencing the curve for study 5 in Figure 5-2, the following can be deduced:

- In 75 percent of the years, the annual water delivery of the SWP is estimated to be at or above 2.70 maf per year (65 percent of 4.13 maf).





- In 50 percent of the years, it is estimated to be at or above 3.50 maf per year (85 percent of 4.13 maf).
- In 25 percent of the years, it is at 4.13 maf per year.

Figures 5-1 and 5-2 depict the estimated reliability for the total of SWP deliveries. Under conditions when almost all contractors are requesting their maximum Table A, such as study 5, this information can be directly applied to individual long-term water supply contracts for the SWP. For example, if a water agency has a maximum SWP Table A amount of 400 taf, at least 260 taf per year (65 percent of 400 taf) is estimated to be delivered 75 percent of the time.

## Potential Adjustments to 1977 CalSim II Table A Deliveries

The CalSim II model, a planning model, is best used for estimating SWP performance over long periods of time. Considerable judgment should be applied when evaluating CalSim II results for shorter periods of time. This is especially true for estimates for a single year. The updated studies (studies 4 and 5) show that the changes in the operations criteria assumed for the SWP produce a delivery estimate of about 5 percent of maximum Delta Table A for the driest year on record (1977). This estimate is lower than the amount actually delivered from the Delta in 1977 (733 taf, 18 percent of maximum Delta Table A), as well as lower than what was shown in *SWP Delivery Reliability Report 2002* (DWR 2003). The discussion below presents some adjustments contractors may consider in estimating Table A deliveries under weather conditions similar to 1977.

In order to understand what led to the lower delivery estimates for 1977, it is best to start with 1975. The year 1975 is a wet year and is immediately followed by two critically dry years (1977 being the driest year on record during the last 80 years of historical hydrology). SWP Table A deliveries estimated in study 4 for 1975, 1976, and 1977 are 3.23 maf, 3.27 maf, and 159 taf, respectively. For study 5 the respective deliveries are 4.13 maf, 3.14 maf, and 187 taf. As currently practiced and allowed under the SWP water supply contracts, many of the contractors would carry over a portion of their allocated Table A water during 1975 and 1976 to succeeding years. In the case of 1977, it is reasonable to assume that up to 500 taf of 1976 allocated Table A water could be carried over to 1977. In addition, due to the slightly conservative delivery-carryover rule curve used in these studies, the minimum SWP storage in San Luis Reservoir for 1977, which occurs during the June-August period, averages about 190 taf for both studies 4 and 5. The minimum pool for the SWP share of San Luis Reservoir is just over 40 taf. In a year as critically dry as 1977, it is also reasonable to assume an additional 150 taf would be made available for deliveries bringing the SWP storage in San Luis Reservoir to minimum pool. After August, the SWP storage in San Luis Reservoir begins to rise. It is reasonable to expect additional deliveries to be made in the September-December period.

In summary, under the hydrologic conditions similar to a critically dry year like 1977, project deliveries can be expected to range from 4 or 5 to 20 percent of Table A, depending upon such factors as the delivery-carryover risk curve applied by SWP operators and the amount of allocated Table A water carried over from the previous year by SWP contractors.

## Additional Analysis of Tables B-3 through B-7 in Appendix B

The information presented earlier in this chapter is helpful in analyzing the delivery reliability of a specific water system receiving a portion of its water supply from the SWP. In addition, the series of data contained in tables B-3 through B-7 are very helpful in analyzing longer periods of time that contain not only dry periods but wetter periods, which can replenish local water supplies if there is a place to store the supply. Analysis of this information can help determine if a local agency has adequate storage for capturing these supplies or if more storage could be utilized in the local water system.

### Cited Reference

[DWR] California Department of Water Resources, Bay-Delta Office. 2003. The State Water Project Delivery Reliability Report 2002. Final.

# Chapter 6. Examples of How to Apply Information

The following two examples illustrate how to use the information presented in this report to develop water supply assessments for a hypothetical SWP contractor. Hypothetical examples illustrating applications of the delivery probability curves and adjustments to the data for a SWP contractor that cannot convey its maximum Table A amount are provided in *The State Water Project Delivery Reliability Report 2002*. Questions regarding the use of the information contained in these reports may be directed to the Department of Water Resources' Bay-Delta Office at (916) 653-1099.

## Example 1

This example uses data directly from Table 5-4 for studies 4 and 5, and employs an allocation methodology that provides a simple means of estimating supplies to each contractor. The data in the table is interpolated for 5-year increments and contained in Table 6-1. In all but the average values in Table 6-1, the estimated percentages of Table A deliveries for the 2005 and the 2025 levels of development differ by one percentage point only. Interpolation between these values is shown in this example for illustration purposes. When values are this close, a valid alternative approach would be to use the same percentage value throughout the entire twenty-year period.

Although the percentage values are calculated using the maximum Delta Table A value, they may be directly applied to generate estimates for SWP deliveries for the entire 20-year period. This is because the Delta Table A value for 2005 is 4.114 maf/yr, 99.5 percent of the maximum Delta Table A value of 4.133 maf/yr. For comparison purposes, the percentage values for studies 1 and 4 based upon a full Table A value of 4.113 maf/yr and 4.133 maf/yr are listed in Tables B-3 and B-6. In addition, the percentages may also be used to estimate the Table A deliveries to SWP contractors in Butte and Plumas counties and Yuba City. The deliveries to these contractors would be calculated using the same method described below.

Table 6-1 shows the average percentage of maximum Delta Table A deliveries for average, single-dry year, and 2-, 4-, and 6-year multiple dry year scenarios from 2005 to 2025 in five-year increments. The maximum Table A amounts of each contractor are listed in Appendix C. Note that Table A amounts can be amended and a contractor's Table A amount over the next 20 years may be less than its maximum over some or all of this period. In this case, the contractor should use the amended Table A amounts for the corresponding years during this period. To use dry years other than those presented in Table 6-1, or to show year-to-year supplies instead of

**Table 6-1 SWP average and dry year Table A delivery from the Delta in five-year intervals for studies 4 and 5**

| Year | SWP Table A delivery from the Delta (in percent of maximum Table A) | | | | | |
|---|---|---|---|---|---|---|
| | Average 1922-1994 | Single dry year 1977 | 2-year drought 1976-1977 | 4-year drought 1931-1934 | 6-year drought 1987-1992 | 6-year drought 1929-1934 |
| 2005 | 68% | 4% | 41% | 32% | 42% | 37% |
| 2010 | 70% | 4% | 41% | 32% | 42% | 37% |
| 2015 | 73% | 4% | 41% | 33% | 42% | 37% |
| 2020 | 75% | 4% | 41% | 33% | 42% | 37% |
| 2025 | 77% | 5% | 40% | 33% | 42% | 38% |





### Tables for Example 1

**Average Annual Values (acre-feet)**

| Water Supply Source | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| State Water Project (Table A) | 68,000 | 70,000 | 73,000 | 75,000 | 77,000 |
| State Water Project (Article 21)[1] | | | | | |
| Groundwater | | | | | |
| Local Surface Water | | | | | |
| Transfers | | | | | |
| Exchanges | | | | | |
| Reclaimed Water | | | | | |
| Other (identify) | | | | | |
| Total | | | | | |

[1] Annual Article 21 amounts vary significantly from year to year. Without the ability to store Article 21 supply, it is not likely to contribute to local supply. See discussion of Article 21 supply in Chapter 5.

**Single Dry Year 1977 conditions (acre-feet)**

| Water Supply Source | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| State Water Project (Table A) | 4,000 | 4,000 | 4,000 | 4,000 | 5,000 |
| State Water Project (Article 21) | 0 | 0 | 0 | 0 | 0 |
| Groundwater | | | | | |
| Local Surface Water | | | | | |
| Transfers | | | | | |
| Exchanges | | | | | |
| Reclaimed Water | | | | | |
| Other (identify) | | | | | |
| Total | | | | | |

**Multiple Dry Year Period 1931-1934 conditions (acre-feet per year)**

| Water Supply Source | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| State Water Project (Table A) | 32,000 | 32,000 | 33,000 | 33,000 | 33,000 |
| State Water Project (Article 21)[1] | | | | | |
| Groundwater | | | | | |
| Local Surface Water | | | | | |
| Transfers | | | | | |
| Exchanges | | | | | |
| Reclaimed Water | | | | | |
| Other (identify) | | | | | |
| Total | | | | | |

[1] Annual Article 21 amounts vary significantly from year to year. Without the ability to store Article 21 supply, it is not likely to contribute to local supply. See discussion of Article 21 supply in Chapter 5.

averages over a multiple-dry year period, see Example 2.

**How to calculate supplies:**

Multiply the contractor's Table A amount for a particular year by the corresponding delivery percentages for that year from Table 6-1 to get an estimated delivery amount, for the average and drought periods, for each 5 year increment from 2005 to 2025.

The example tables show the SWP Table A deliveries projected to be available to a hypothetical contractor with a maximum Table A amount of 100,000 af, on average and for the various drought periods. For this example, the supplies shown for the multiple-dry year period are average supplies over the four-year drought from 1931-1934. Data from other year types, although not required in an urban water management plan, could also be presented this way.

## Example 2

This example is similar to Example 1 but allows a contractor to select alternative single year or multiple-dry year sequences other than those presented in Table 6-1. This option might be selected if analyzing different hydrologic year(s) makes more sense given a contractor's other supply sources, or given the locally acceptable risk level for water delivery shortages.

This example can also be used to identify supplies projected to be available in each year of a multiple-dry year period. While the Water Code does not specifically require this, the *Urban Water Management Plan Guidebook* suggests showing year-to-year supplies (see the *UWMP Guidebook*, Section 7, Step 3).

**Where to find the data**

Choose a single year or multiple-year sequence from Tables B-6 and B-7 to represent single-dry year and multiple-dry year scenarios. Table B-6 contains the percent of maximum Table A deliveries under all 73 hydrologic years in the updated model study for 2005. Table B-7 contains the percent of maximum Table A deliveries under all 73 hydrologic years in the updated model study for 2025.

**How to calculate supplies**

Multiply the contractor's Table A amount for a particular year by the percent of maximum Table A deliveries for the selected years, to get an estimated delivery amount for the years selected, for 2005 and 2025. Values for years between 2005 and 2025 can be linearly interpolated.

The following tables show the SWP Table A deliveries projected to be available to a hypothetical contractor with a maximum Table A amount of 100,000 af, in a single dry year and year-to-year over a multiple dry year period. For this example, the single dry year selected is for 1988 conditions, and the multiple dry year period selected is the three-year period from 1990-1992. In showing year-to-year supplies for the multiple dry year period, these year-to-year supplies should be shown for each five-year increment during the 20-year projection period.

### Tables for Example 2

**Single Dry Year**
**1988 conditions**
**(acre-feet)**

| Water Supply Source | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| State Water Project (Table A) | 21,000 | 18,000 | 15,000 | 13,000 | 10,000 |
| State Water Project (Article 21) | 0 | 0 | 0 | 0 | 0 |
| Groundwater | | | | | |
| Local Surface Water | | | | | |
| Transfers | | | | | |
| Exchanges | | | | | |
| Reclaimed Water | | | | | |
| Other (identify) | | | | | |
| Total | | | | | |





### Tables for Example 2 (cont.)

**Multiple Dry Year Period 1990-1992**
**1990 conditions**
**(acre-feet per year)**

| Water Supply Source | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| State Water Project (Table A) | 27,000 | 25,000 | 24,000 | 22,000 | 21,000 |
| State Water Project (Article 21) | 0 | 0 | 0 | 0 | 0 |
| Groundwater | | | | | |
| Local Surface Water | | | | | |
| Transfers | | | | | |
| Exchanges | | | | | |
| Reclaimed Water | | | | | |
| Other (identify) | | | | | |
| Total | | | | | |

**Multiple Dry Year Period 1990-1992**
**1991 conditions**
**(acre-feet per year)**

| Water Supply Source | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| State Water Project (Table A) | 25,000 | 24,000 | 23,000 | 22,000 | 21,000 |
| State Water Project (Article 21) | 0 | 0 | 0 | 0 | 0 |
| Groundwater | | | | | |
| Local Surface Water | | | | | |
| Transfers | | | | | |
| Exchanges | | | | | |
| Reclaimed Water | | | | | |
| Other (identify) | | | | | |
| Total | | | | | |

**Multiple Dry Year Period 1990-1992**
**1992 conditions**
**(acre-feet per year)**

| Water Supply Source | 2005 | 2010 | 2015 | 2020 | 2025 |
|---|---|---|---|---|---|
| State Water Project (Table A) | 34,000 | 34,000 | 35,000 | 35,000 | 35,000 |
| State Water Project (Article 21) | 0 | 0 | 0 | 0 | 0 |
| Groundwater | | | | | |
| Local Surface Water | | | | | |
| Transfers | | | | | |
| Exchanges | | | | | |
| Reclaimed Water | | | | | |
| Other (identify) | | | | | |
| Total | | | | | |

# Appendix A. 2005 Delivery Reliability Report CalSim II Modeling Assumptions

Two versions of the model are used for this report. Studies 1, 2 and 3 are based on the May 2002 benchmark study version. The updated studies (4 and 5) use the most recent version, which was developed for the 2004 Long-Term Central Valley Project Operations Criteria and Plan (OCAP). The key assumption differences between the May 2002 benchmark version and the 2004 OCAP version are listed below.

1. Temperature flow below Keswick Dam was changed from a fixed time series flow to a dynamic storage dependent flow.

2. Relaxation of criteria for flow below Nimbus Dam when Folsom Lake storage drops below 300 thousand acre-feet.

3. Navigation control point flow criteria were modified from being dependent on water year type to being dependent on CVP agricultural allocation levels. Criteria were also relaxed for very low allocation years.

4. Clear Creek Tunnel target flows were modified to match the latest Trinity EIR analysis.

5. Addition of a minimum pumping level at Banks Pumping Plant of 300 cubic feet per second.

6. Addition of a minimum pumping level at Tracy Pumping Plant of 600 cubic feet per second.

7. Addition of flow requirements for flow at the mouth of the Feather River for Settlement Contractors.

8. Delivery-carryover relationship was adjusted to reduce delivery targets and increase carryover in critically dry years.

9. Addition of Lake Oroville end-of-September carryover target storage rule.

10. Five-step study setup modified to isolate (b)(2) accounting from "with Project" conditions.

11. Modification of American River demands as described in Tables A-2 and A-3.

12. Modification of Contra Costa Water District demands to include the effect of Los Vaqueros Reservoir operations.

13. The minimum flow of the Trinity River below Lewiston Dam in study 4 ranges from 369 to 453 thousand acre-feet per year depending on water year type. All other studies used in this report assume the Trinity River minimum flow has a greater range from 369 to 815 thousand acre-feet per year. This greater range of Trinity River minimum flows represents the Trinity Environmental Impact Statement Preferred Alternative.

14. Study 5 assumes the implementation of Freeport Regional Water Project, including modified East Bay Municipal Utility District operations on the Mokelumne River.

15. Implementation of May 2003 CVPIA 3406 (b)(2) decision and other changes:
    a. Streamlining actions to simplify analysis of the results.





    b. Anadromous Fish Restoration Program table updates to better represent management of (b)(2) water under the May 2003 (b)(2) decision.
    c. Action triggering modifications to attempt to meet 200 thousand-acre feet target during October through January period.

16. Environmental Water Account (EWA) changes include:
    a. Streamlining actions and coordination with (b)(2) actions.
    b. EWA purchase amount increase to a maximum of 250 thousand acre-feet per year.
    c. Addition of storage debt carryover accounting, including debt spill at San Luis Reservoir.
    d. Addition of EWA asset takeover by SWP and CVP at San Luis Reservoir when reservoir space utilized by EWA is needed for project operations.

All studies assume current Banks Pumping Plant capacity, existing conveyance capacity of the upper Delta-Mendota Canal/California Aqueduct system, and current SWP/CVP operations agreements.

The following table is a complete list of the study assumptions.

Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions

| | Study 1 2001 Study, 2003 Report | Study 4 2005 Study, Updated Studies | Study 2 2021A Study, 2003 Report | Study 3 2021B Study, 2003 Report | Study 5 2025 Study, Updated Studies |
|---|---|---|---|---|---|
| **Period of Simulation** | 73 years (1922-1994) | Same | Same | Same | Same |
| **HYDROLOGY** | | | | | |
| **Level of Development (Land Use)** | 2001 Level, DWR Bulletin 160-98[1] | Same as Study 1 | 2020 Level, DWR Bulletin 160-98 | Same as Study 2 | Same as Study 2 |
| **Demands** | | | | | |
| **North of Delta (except American River)** | | | | | |
| CVP | Land Use based, limited by Full Contract | Same | Same | Same | Same |
| SWP (FRSA) | Land Use based, limited by Full Contract | Same | Same | Same | Same |
| Non-Project | Land Use based | Same | Same | Same | Same |
| CVP Refuges | Firm Level 2 | Same | Same | Same | Same |
| **American River Basin** | | | | | |
| Water rights | 2001[2] | 2001[3] | 2020[4] | Same as Study 2 | 2020, as projected by Water Forum Analysis[5] |
| CVP | 2001[2] | 2001[3] | 2020[6] | Same as Study 2 | 202 0, as projected by Water Forum Analysis[7] |
| **San Joaquin River Basin** | | | | | |
| Friant Unit | Regression of historical | Same | Same | Same | Same |
| Lower Basin | Fixed annual demands | Same | Same | Same | Same |
| Stanislaus River Basin | New Melones Interim Operations Plan | Same | Same | Same | Same |
| **South of Delta** | | | | | |
| CVP | Full Contract | Same | Same | Same | Same |
| CCWD | 143 TAF/YR[8] | 124 TAF/YR[8] | 151 TAF/YR[8] | Same as Study 2 | 158 TAF/YR[8] |









Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions (cont.)

| | Study 1 2001 Study, 2003 Report | Study 4 2005 Study, Updated Studies | Study 2 2021A Study, 2003 Report | Study 3 2021B Study, 2003 Report | Study 5 2025 Study, Updated Studies |
|---|---|---|---|---|---|
| SWP (w/ North Bay Aqueduct) | 3.0-4.1 MAF/YR | 2.3-3.9 MAF/YR | 3.3-4.1 MAF/YR | 4.1 MAF/YR | 3.9-4.1 MAF/YR |
| SWP Article 21 Demand | MWDSC up to 50 TAF/month, Dec-Mar, others up to 84 TAF/month | MWDSC up to 100 TAF/ month, Dec-Mar, others up to 84 TAF/month | Same as Study 1 | Same as Study 1 | Same as Study 4 |
| **FACILITIES** | | | | | |
| Freeport Regional Water Project | None | Same as Study 1 | Same as Study 1 | Same as Study 1 | Included[9] |
| Banks Pumping Capacity | 6680 cfs | Same | Same | Same | Same |
| Tracy Pumping Capacity | 4200 cfs + deliveries upstream of DMC constriction | Same | Same | Same | Same |
| **REGULATORY STANDARDS** | | | | | |
| **Trinity River** | | | | | |
| Minimum Flow below Lewiston Dam | Trinity EIS Preferred Alternative (369-815 TAF/YR) | 369-453 TAF/YR | Same as Study 1 | Same as Study 1 | Same as Study 1 |
| Trinity Reservoir End-of-September Minimum Storage | Trinity EIS Preferred Alternative (600 TAF as able) | Same | Same | Same | Same |
| **Clear Creek** | | | | | |
| Minimum Flow below Whiskeytown Dam | Downstream water rights, 1963 USBR Proposal to FWS and NPS, and FWS use of CVPIA 3406(b)(2) water | Same | Same | Same | Same |
| **Upper Sacramento River** | | | | | |
| Shasta Lake End-of-September Minimum Storage | SWRCB WR 1993 Winter-run Biological Opinion (1900 TAF) | Same | Same | Same | Same |

Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions (cont.)

| | Study 1<br>2001 Study,<br>2003 Report | Study 4<br>2005 Study,<br>Updated Studies | Study 2<br>2021A Study,<br>2003 Report | Study 3<br>2021B Study,<br>2003 Report | Study 5<br>2025 Study,<br>Updated Studies |
|---|---|---|---|---|---|
| Minimum Flow below Keswick Dam | Flows for SWRCB WR 90-5 and 1993 Winter-run Biological Opinion temperature control, and FWS use of CVPIA 3406(b)(2) water | Same | Same | Same | Same |
| **Feather River** | | | | | |
| Minimum Flow below Thermalito Diversion Dam | 1983 DWR, DFG Agreement (600 CFS) | Same | Same | Same | Same |
| Minimum Flow below Thermalito Afterbay outlet | 1983 DWR, DFG Agreement (750-1700 CFS) | Same | Same | Same | Same |
| **American River** | | | | | |
| Minimum Flow below Nimbus Dam | SWRCB D-893 (see accompanying Operations Criteria), and FWS use of CVPIA 3406(b)(2) water | Same | Same | Same | Same |
| Minimum Flow at H Street Bridge | SWRCB D-893 | Same | Same | Same | Same |
| **Lower Sacramento River** | | | | | |
| Minimum Flow near Rio Vista | SWRCB D-1641 | Same | Same | Same | Same |
| **Mokelumne River** | | | | | |
| Minimum Flow below Camanche Dam | FERC 2916-029, 1996 (Joint Settlement Agreement) (100-325 CFS) | Same | Same | Same | Same |
| Minimum Flow below Woodbridge Diversion Dam | FERC 2916-029, 1996 (Joint Settlement Agreement) (25-300 CFS) | Same | Same | Same | Same |
| **Stanislaus River** | | | | | |
| Minimum Flow below Goodwin Dam | 1987 USBR, DFG agreement, and FWS use of CVPIA 3406(b)(2) water | Same | Same | Same | Same |









Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions (cont.)

| | Study 1<br>2001 Study,<br>2003 Report | Study 4<br>2005 Study,<br>Updated Studies | Study 2<br>2021A Study,<br>2003 Report | Study 3<br>2021B Study,<br>2003 Report | Study 5<br>2025 Study,<br>Updated Studies |
|---|---|---|---|---|---|
| Minimum Dissolved Oxygen | SWRCB D-1422 | Same | Same | Same | Same |
| **Merced River** | | | | | |
| Minimum Flow below Crocker-Huffman Diversion Dam | Davis-Grunsky (180-220 CFS, Nov-Mar), and Cowell Agreement | Same | Same | Same | Same |
| Minimum Flow at Shaffer Bridge | FERC 2179 (25-100 CFS) | Same | Same | Same | Same |
| **Tuolumne River** | | | | | |
| Minimum Flow at Lagrange Bridge | FERC 2299-024, 1995 (Settlement Agreement) (94-301 TAF/YR) | Same | Same | Same | Same |
| **San Joaquin River** | | | | | |
| Maximum Salinity near Vernalis | SWRCB D-1641 | Same | Same | Same | Same |
| Minimum Flow near Vernalis | SWRCB D-1641, and Vernalis Adaptive Management Program per San Joaquin River Agreement | Same | Same | Same | Same |
| **Sacramento River-San Joaquin River Delta** | | | | | |
| Delta Outflow Index (Flow and Salinity) | SWRCB D-1641 | Same | Same | Same | Same |
| Delta Cross Channel Gate Operation | SWRCB D-1641 | Same | Same | Same | Same |
| Delta Exports | SWRCB D-1641, FWS use of CVPIA 3406(b)(2) water and CALFED Fisheries Agencies use of EWA assets | Same | Same | Same | Same |
| **OPERATIONS CRITERIA** | | | | | |
| **Subsystem** | | | | | |
| **Upper Sacramento River** | | | | | |
| Flow Objective for Navigation (Wilkins Slough) | 3,500-5,000 CFS based on Lake Shasta storage condition | 3,250-5,000 CFS based on CVP Ag allocation levels | Same as Study 1 | Same as Study 1 | Same as Study 4 |

Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions (cont.)

| | Study 1 2001 Study, 2003 Report | Study 4 2005 Study, Updated Studies | Study 2 2021A Study, 2003 Report | Study 3 2021B Study, 2003 Report | Study 5 2025 Study, Updated Studies |
|---|---|---|---|---|---|
| **American River** | | | | | |
| Folsom Dam Flood Control | SAFCA, Interim re-operation of Folsom Dam, Variable 400/670 (without outlet modifications) | Same | Same | Same | Same |
| Flow below Nimbus Dam | Operations criteria corresponding to SWRCB D-893 required minimum flow | Same | Same | Same | Same |
| Sacramento Water Forum Mitigation Water | None | Same as Study 1 | Sacramento Water Forum (up to 47 TAF/YR in dry years)[9] | Same as Study 2 | Same as Study 2 |
| **Feather River** | | | | | |
| Flow at Mouth | No criteria | Maintain the DFG/DWR flow target above Verona or 2800 cfs for Apr-Sep dependent on Oroville inflow and FRSA allocation | Same as Study 1 | Same as Study 1 | Same as Study 4 |
| **Stanislaus River** | | | | | |
| Flow below Goodwin Dam | 1997 New Melones Interim Operations Plan | Same | Same | Same | Same |
| **San Joaquin River** | | | | | |
| Flow near Vernalis | San Joaquin River Agreement in support of the Vernalis Adaptive Management Program | Same | Same | Same | Same |
| **System-wide** | | | | | |
| **CVP Water Allocation** | | | | | |
| CVP Settlement and Exchange | 100% (75% in Shasta Critical years) | Same | Same | Same | Same |
| CVP Refuges | 100% (75% in Shasta Critical years) | Same | Same | Same | Same |







Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions (cont.)

| | Study 1 2001 Study, 2003 Report | Study 4 2005 Study, Updated Studies | Study 2 2021A Study, 2003 Report | Study 3 2021B Study, 2003 Report | Study 5 2025 Study, Updated Studies |
|---|---|---|---|---|---|
| CVP Agriculture | 100% - 0% based on supply (reduced by 3406(b)(2) allocation) | Same | Same | Same | Same |
| CVP Municipal & Industrial | 100% - 50% based on supply (reduced by 3406(b)(2) allocation) | Same | Same | Same | Same |
| **SWP Water Allocation** | | | | | |
| North of Delta (FRSA) | Contract specific | Same | Same | Same | Same |
| South of Delta | Based on supply; Monterey Agreement | Same | Same | Same | Same |
| **CVP/SWP Coordinated Operations** | | | | | |
| Sharing of Responsibility for In-Basin-Use | 1986 Coordinated Operations Agreement | Same | Same | Same | Same |
| Sharing of Surplus Flows | 1986 Coordinated Operations Agreement | Same | Same | Same | Same |
| Sharing of Restricted Export Capacity | Equal sharing of export capacity under SWRCB D-1641; use of CVPIA 3406(b)(2) only restricts CVP exports; EWA use restricts CVP and/or SWP exports as directed by CALFED Fisheries Agencies | Same | Same | Same | Same |
| **Transfers** | | | | | |
| Dry Year Program | None | Same | Same | Same | Same |
| Phase 8 | None | Same | Same | Same | Same |
| MWDSC/CVP Settlement Contractors | None | Same | Same | Same | Same |

Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions (cont.)

| | Study 1 2001 Study, 2003 Report | Study 4 2005 Study, Updated Studies | Study 2 2021A Study, 2003 Report | Study 3 2021B Study, 2003 Report | Study 5 2025 Study, Updated Studies |
|---|---|---|---|---|---|
| **CVP/SWP Integration** | | | | | |
| Dedicated Conveyance at Banks | None | Same | Same | Same | Same |
| NOD Accounting Adjustments | None | Same | Same | Same | Same |
| CVPIA 3406(b)(2) | May 2002 benchmark study assumptions | Dept of Interior 2003 Decision | Same as Study 1 | Same as Study 1 | Same as Study 4 |
| Allocation | 800 TAF/YR (600 TAF/YR in Shasta Critical years) | 800 TAF/YR, 700 TAF/YR in 40-30-30 Dry Years, and 600 TAF/YR in 40-30-30 Critical years | Same as Study 1 | Same as Study 1 | Same as Study 4 |
| Actions | AFRP flow objectives (Oct-Jan), CVP export reduction (Dec-Jan), 1995 WQCP (up to 450 TAF/YR), VAMP (Apr 15- May 16) CVP export restriction, Post (May 16-31) VAMP CVP export restriction, Ramping of CVP export (Jun), Pre (Apr 1-15) VAMP CVP export restriction, CVP export reduction (Feb-Mar), Additional Upstream Releases (Feb-Sep) | 1995 WQCP, Fish flow objectives (Oct-Jan), VAMP (Apr 15- May 16) CVP export restriction, 3000 CFS CVP export limit in May and June (D1485 Striped Bass continuation), Post (May 16-31) VAMP CVP export restriction, Ramping of CVP export (Jun), Upstream Releases (Feb-Sep) | Same as Study 1 | Same as Study 1 | Same as Study 4 |
| Accounting adjustments per May 2003 Interior Decision | None | No limit on responsibility for non-discretionary D1641 requirements no Reset with the Storage metric and no Offset with the Release and Export metrics | Same as Study 1 | Same as Study 1 | Same as Study 4 |





Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions (cont.)

| | Study 1 2001 Study, 2003 Report | Study 4 2005 Study, Updated Studies | Study 2 2021A Study, 2003 Report | Study 3 2021B Study, 2003 Report | Study 5 2025 Study, Updated Studies |
|---|---|---|---|---|---|
| **CALFED Environmental Water Account** | | | | | |
| Actions | Total exports restricted to 4,000 cfs, 1 wk/mon, Dec-Mar (wet year: 2 wk/mon), VAMP (Apr 15- May 16) export restriction, Pre (Apr 1-15) and Post (May 16-31) VAMP export restriction, Ramping of export (Jun) | Dec-Feb reduce total exports by 50 TAF/month relative to total exports without EWA; VAMP (Apr 15- May 16) export restriction on SWP; Post (May 16-31) VAMP export restriction on SWP and potentially on CVP if B2 Post-VAMP action is not taken; Ramping of exports (Jun) | Same as Study 1 | Same as Study 1 | Same as Study 4 |
| Assets | 50% of use of JPOD, 50% of any CVPIA 3406(b)(2) or ERP releases pumped by SWP, flexing of Delta Export/Inflow Ratio (not explicitly modeled), dedicated 500 CFS increase of Jul-Sep Banks PP capacity, north-of-Delta (35 TAF/Yr) and south-of-Delta purchases (50-200 TAF/Yr), 100 TAF/Yr from south-of-Delta source shifting agreements, and 200 TAF/YR south-of-Delta groundwater storage capacity | Fixed Water Purchases 250 TAF/yr, 230 TAF/yr in 40-30-30 dry years, 210 TAF/yr in 40-30-30 critical years. The purchases range from 0 TAF in Wet Years to approximately 153 TAF in Critical Years NOD, and 57 TAF in Critical Years to 250 TAF in Wet Years SOD. Variable assets include the following: used of 50% JPOD export capacity, acquisition of 50% of any CVPIA 3406(b)(2) releases pumped by SWP, flexing of Delta Export/Inflow Ratio (post-processed from CalSim II results), dedicated 500 CFS pumping capacity at Banks in Jul-Sep | Same as Study 1 | Same as Study 1 | Same as Study 4 |

| | Study 1 2001 Study, 2003 Report | Study 2 2021A Study, 2003 Report | Study 3 2021B Study, 2003 Report | Study 4 2005 Study, Updated Studies | Study 5 2025 Study, Updated Studies |
|---|---|---|---|---|---|
| Debt restrictions | No planned carryover of debt past Sep, no reset of unpaid debt, debt carried past Sep paid back by Feb | Same as Study 1 | Same as Study 1 | Delivery debt paid back in full upon assessment; Storage debt paid back over time based on association priorities; SOD and NOD debt carryover is allowed; SOD debt carryover is explicitly managed or spilled; NOD debt carryover must be spilled; SOD and NOD asset carryover is allowed. | Same as Study 4 |

Table A-1 2005 Delivery Reliability Report CalSim II Modeling Assumptions (cont.)

[1] 2000 Level of Development defined by linearly interpolated values from the 1995 Level of Development and 2020 Level of Development from DWR Bulletin 160-98

[2] 1998 level demands defined in Sacramento Water Forum's EIR with a few updated entries.

[3] Presented in attached Table 2001 American River Demand Assumptions

[4] Sacramento Water Forum 2025 level demands defined in Sacramento Water Forum's EIR.

[5] Presented in attached Table 2020 American River Demand Assumptions

[6] Sacramento Water Forum 2025 level demands defined in Sacramento Water Forum's EIR. Freeport Alternative defined in EBMUD Supplemental Water Supply Project REIR/SEIS.

[7] Same as footnote 5 but modified with PCWA 35 TAF CVP contract supply diverted at the new American River PCWA Pump Station

[8] Data directions include operations of Lake Vaqueros Reservoir and represent average annual diversion

[9] Includes modified EBMUD operations of the Mokelumne River

[10] This is implemented only in the PCWA Middle Fork Project releases used in defining the CALSIM II inflows to Folsom Lake





Table A-2 2001 American River Demand Assumptions

| Location / Purveyor | Allocation Type (maximum acre-feet) | | | | | | |
|---|---|---|---|---|---|---|---|
| | CVP AG | CVP MI | CVP Settlement / Exchange | Water Rights / Non-CVP / No Cuts | CVP Refuge | Total |
| **Auburn Dam Site (D300)** | | | | | | |
| Placer County Water Agency | 0 | 0 | 0 | 8,500 | 0 | 8,500 |
| Total | 0 | 0 | 0 | 8,500 | 0 | 8,500 |
| **Folsom Reservoir (D8)** | | | | | | |
| Sacramento Suburban | 0 | 0 | 0 | 0 | 0 | 0 |
| City of Folsom (includes P.L. 101-514) | 0 | 0 | 0 | 20,000 | 0 | 20,000 |
| Folsom Prison | 0 | 0 | 0 | 2,000 | 0 | 2,000 |
| San Juan Water District (Placer County) | 0 | 0 | 0 | 10,000 | 0 | 10,000 |
| San Juan Water District (Sacramento County) (includes P.L. 101-514) | 0 | 11,200 | 0 | 33,000 | 0 | 44,200 |
| El Dorado Irrigation District | 0 | 7,550 | 0 | 0 | 0 | 7,550 |
| El Dorado Irrigation District (P.L. 101-514) | 0 | 0 | 0 | 0 | 0 | 0 |
| City of Roseville | 0 | 32,000 | 0 | 0 | 0 | 32,000 |
| Placer County Water Agency | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 50,750 | 0 | 65,000 | 0 | 115,750 |
| **Folsom South Canal (D9)** | | | | | | |
| So. Cal WC/ Arden Cordova WC | 0 | 0 | 0 | 3,500 | 0 | 3,500 |
| California Parks and Recreation | 0 | 100 | 0 | 0 | 0 | 100 |
| SMUD (export) | 0 | 0 | 0 | 15,000 | 0 | 15,000 |
| South Sacramento County Agriculture (export, SMUD transfer) | 0 | 0 | 0 | 0 | 0 | 0 |
| Canal Losses | 0 | 0 | 0 | 1,000 | 0 | 1,000 |
| Total | 0 | 100 | 0 | 19,500 | 0 | 19,600 |
| **Nimbus to Mouth (D302)** | | | | | | |
| City of Sacramento | 0 | 0 | 0 | 63,335 | 0 | 63,335 |
| Arcade Water District | 0 | 0 | 0 | 2,000 | 0 | 2,000 |
| Carmichael Water District | 0 | 0 | 0 | 8,000 | 0 | 8,000 |
| Total | 0 | 0 | 0 | 73,335 | 0 | 73,335 |
| **Sacramento River (D162)** | | | | | | |
| Placer County Water Agency | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 |
| **Sacramento River (D167/D168)** | | | | | | |
| City of Sacramento | 0 | 0 | 0 | 38,665 | 0 | 38,665 |
| Sacramento County Water Agency (SMUD transfer) | 0 | 0 | 0 | 0 | 0 | 0 |
| Sacramento County Water Agency (P.L. 101-514) | 0 | 0 | 0 | 0 | 0 | 0 |
| EBMUD (export) | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 0 | 38,665 | 0 | 38,665 |
| **Total from the American River** | 0 | 50,850 | 0 | 166,335 | 0 | 217,185 |

Table A-3 2020 American River Demand Assumptions

| Location / Purveyor | Allocation Type (maximum acre-feet) | | | | | | Folsom Unimpaired Inflow (FUI) | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | CVP AG | CVP MI | CVP Settlement / Exchange | Water Rights / Non-CVP / No Cuts | CVP Refuge | Total | FUI = Total TAF (Mar – Sep) + 60 TAF | | | |
| **Auburn Dam Site (D300)** | | | | | | | | | | |
| Placer County Water Agency | 0 | 35,000 | 0 | 35,500 | 0 | 70,500 | 70,500 | 70,500 | 70,500 | 1/2/3/12 |
| Total | 0 | 35,000 | 0 | 35,500 | 0 | 70,500 | 70,500 | 70,500 | 70,500 | |
| **Folsom Reservoir (D8)** | | | | | | | | | | |
| Sacramento Suburban | 0 | 0 | 0 | 29,000 | 0 | 29,000 | 29,000 | 0 | 0 | 4/5/11 |
| City of Folsom (includes P.L. 101-514) | 0 | 7,000 | 0 | 27,000 | 0 | 34,000[1] | 34,000 | 34,000 | 20,000 | 1/2/3 |
| Folsom Prison | 0 | 0 | 0 | 5,000 | 0 | 5,000 | 5,000 | 5,000 | 5,000 | |
| San Juan Water District (Placer County) | 0 | 0 | 0 | 25,000 | 0 | 25,000 | 25,000 | 25,000 | 10,000 | 1/2/3/11 |
| San Juan Water District (Sac County) (includes P.L. 101-514) | 0 | 24,200 | 0 | 33,000 | 0 | 57,200 | 57,200 | 57,200 | 44,200 | 1/2/3 |
| El Dorado Irrigation District | 0 | 7,550 | 0 | 17,000 | 0 | 24,550 | 24,550 | 24,550 | 22,550 | 1/2/3 |
| El Dorado Irrigation District (P.L. 101-514) | 0 | 7,500 | 0 | 0 | 0 | 7,500 | 7,500 | 7,500 | 0 | 1/2/3 |
| City of Roseville | 0 | 32,000 | 0 | 30,000 | 0 | 62,000 | 54,900 | 54,900 | 39,800 | 1/2/3/11/12 |
| Placer County Water Agency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| Total | 0 | 78,250 | 0 | 166,000 | 0 | 244,250 | 237,150 | 208,150 | 141,550 | |
| **Folsom South Canal (D9)** | | | | | | | | | | |
| So. Cal WC/ Arden Cordova WC | 0 | 0 | 0 | 5,000 | 0 | 5,000 | 5,000 | 5,000 | 5,000 | |
| California Parks and Recreation | 0 | 5,000 | 0 | 0 | 0 | 5,000 | 5,000 | 5,000 | 5,000 | |
| SMUD (export) | 0 | 15,000 | 0 | 15,000 | 0 | 30,000 | 30,000 | 30,000 | 15,000 | 1/2/3 |
| South Sacramento County Agriculture (export, SMUD transfer) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1/2/3 |
| Canal Losses | 0 | 0 | 0 | 1,000 | 0 | 1,000 | 1,000 | 1,000 | 1,000 | |
| Total | 0 | 20,000 | 0 | 21,000 | 0 | 41,000 | 41,000 | 41,000 | 26,000 | |
| **Nimbus to Mouth (D302)** | | | | | | | | | | |
| City of Sacramento | 0 | 0 | 0 | 96,300 | 0 | 96,300 | 96,300 | 96,300 | 50,000 | 6/7/8 |





Table A-3 2020 American River Demand Assumptions (cont.)

| Location / Purveyor | Allocation Type (maximum acre-feet) | | | | | | Folsom Unimpaired Inflow (FUI) | | | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| | CVP AG | CVP MI | CVP Settlement / Exchange | Water Rights / Non-CVP / No Cuts | CVP Refuge | Total | FUI = Total TAF (Mar – Sep) + 60 TAF | | | |
| Arcade Water District | 0 | 0 | 0 | 11,200 | 0 | 11,200 | 11,200 | 11,200 | 3,500 | 13 |
| Carmichael Water District | 0 | 0 | 0 | 12,000 | 0 | 12,000 | 12,000 | 12,000 | 12,000 | |
| Total | 0 | 0 | 0 | 119,500 | 0 | 119,500 | 119,500 | 119,500 | 65,500 | |
| **Sacramento River (D162)** | | | | | | | | | | |
| Placer County Water Agency | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| **Sacramento River (D167/D168)** | | | | | | | | | | |
| City of Sacramento | 0 | 0 | 0 | 34,300 | 0 | 34,300 | 34,300 | 34,300 | 80,600 | 8 |
| Sacramento County Water Agency (SMUD transfer) | 0 | 30,000 | 0 | 0 | 0 | 30,000 | | | | 10 |
| Sacramento County Water Agency (P.L. 101-514) | 0 | 15,000 | 0 | 0 | 0 | 15,000 | | | | 10 |
| EBMUD (export) | 0 | 133,000 | 0 | 0 | 0 | 133,000 | | | | |
| Total | 0 | 178,000 | 0 | 34,300 | 0 | 212,300 | 34,300 | 34,300 | 80,600 | |
| Total demands from the American River | 0 | 133,250 | 0 | 342,000 | 0 | 475,250 | 468,150 | 439,150 | 303,550 | |

Notes

[1] Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 950,000 af.

[2] Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 950,000 af but greater than 400,000 af.

[3] Driest years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 400,000 af.

[4] Wet/average years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is greater than 1,600,000 af.

[5] Drier years for this diverter are defined as those years when the projected March through November unimpaired inflow to Folsom Reservoir is less than 1,600,000 af.

[6] Wet/average years as it applies to the City of Sacramento are time periods when the flows bypassing the E. A. Fairbairn Water Treatment Plant diversion exceed the "Hodge flows."

[7] Drier years are time periods when the flows bypassing the City's E.A. Fairbairn Water Treatment Plant diversion do not exceed the "Hodge flows."

[8] For modeling purposes, it is assumed that the City of Sacramento's total annual diversions from the American and Sacramento River in year 2030 would be 130,600 af.

[10] The total demand for Sacramento County Water Agency would be up to 78,000 af. The 45,000 af represents firm entitlements; the additional 33,000 af of demand is expected to be met by intermittent surplus supply. The intermittent supply is subject to Reclamation reduction (50%) in dry years.

[11] Water Rights Water provided by releases from PCWA's Middle Fork Project: inputs into upper American River model must be consistent with these assumptions.

[12] Demand requires "Replacement Water" as indicated below

[13] Arcade WD demand modeled as step function: one demand when FUI > 400, another demand when FUI < 400.

# Appendix B. Results of Report Studies

A study to estimate the supply reliability of the State Water Project is done using a computer program that simulates the operation of the SWP on a monthly basis over a 73-year historical record of rainfall and runoff (1922–1994). The simulation model integrates all the relevant water resource components and calculates key water management parameters, such as:

- the amount of water released from reservoirs in the Sacramento-San Joaquin valleys,
- the amount of water required to maintain Delta water quality standards,
- the amount of water to be pumped from the Delta by the SWP and the Central Valley Project (CVP), and
- the amount of water that can be delivered by each of these projects.

The information required to run the simulation is referred to as the "model input." The most significant categories of input are:

- the physical description of the water system facilities (maximum pumping or release capacity, maximum reservoir storages, etc.);
- institutional requirements (delivery contract requirements, Delta water quality standards, the operations agreement between the SWP and CVP, endangered species requirements, and other requirements of federal and state laws, etc);
- hydrology (river and stream flows adjusted for water use in the source areas); and
- the level of SWP water demand.

CalSim II is the current version of the computer simulation model used to estimate SWP delivery reliability. All versions of CalSim employ commercially available linear programming software as a solution device. The application of the software, graphical user interface, and input/output devices are discussed in the documentation for CalSim.

The model studies selected for this report answer two questions.

1. "What is the estimated current delivery reliability of the SWP?" and
2. "What is the estimate for SWP deliveries in the year 2025, if there were no new facilities or improvements to existing facilities, SWP water demand increased, and the institutional requirements existing today were in place?"

The key study assumptions are shown in Table B-1 and listed in more detail in Chapter 4 and Appendix A. Additional discussions of these studies are on DWR's Modeling Branch's Website for the SWP Delivery Reliability Report 2002 (DWR 2003) studies and on the US Bureau of Reclamation's Website for Operations Criteria and Plan (OCAP) studies (http://modeling.water.ca.gov/hydro/studies/SWPReliability/index.html and http://www.usbr.gov/mp/cvo/ocap_page.html, respectively).

## Study Results

The annual delivery amounts calculated by the supply reliability studies are contained in Tables B-3 through B-7 at the back of this appendix. The tables show the demand level in thousand acre-feet (taf), the amount of delivery from the Delta, and percent of full Delta Table A calculated for each year of simulation for the five studies. Delta Table A refers to the total of the Table A amounts for each of the SWP contractors receiving water from the Delta. Of the 29 SWP contractors, 26 receive their deliveries from the Delta. The total maximum Table A amount for all SWP contractors is 4.173 maf/year. Of this amount, 4.133 maf/yr is the maximum Delta Table A amount.





Table B-1 Key study assumptions

| Study | Study name | Level of development (year) | SWP Table A demand (maf/year) | SWP Article 21 demand (taf/month) | Model version |
|---|---|---|---|---|---|
| | | SWP Delivery Reliability Report (2003) | | | |
| 1 | 2001 Study | 2001 | 3.0–4.1 | 0–84, Apr–Nov<br>50–134, Dec–Mar | May 2002 benchmark |
| 2 | 2021A Study | 2021 | 3.3–4.1 | 0–84, Apr–Nov<br>50–134, Dec–Mar | May 2002 benchmark |
| 3 | 2021B Study | 2021 | 4.1 | 0–84, Apr–Nov<br>50–134, Dec–Mar | May 2002 benchmark |
| | | Updated Studies | | | |
| 4 | 2005 Study | 2005 | 2.3–3.9 | 0–84, Apr–Nov<br>100–184, Dec–Mar | 2004 OCAP |
| 5 | 2025 Study | 2025 | 3.9–4.1 | 0–84, Apr–Nov<br>100–184, Dec–Mar | 2004 OCAP |

maf = million acre-feet
OCAP = 2004 Long-Term Central Valley Project Operations Criteria and Plan
taf = thousand acre-feet

Table B-2 SWP average and dry year Table A delivery from the Delta for studies 4 and 5

| Year | SWP Table A delivery from the Delta (in percent of maximum Table A) | | | | | |
|---|---|---|---|---|---|---|
| | Average 1922-1994 | Single dry year 1977 | 2-year drought 1976-1977 | 4-year drought 1931-1934 | 6-year drought 1987-1992 | 6-year drought 1929-1934 |
| 2005 | 68% | 4% | 41% | 32% | 42% | 37% |
| 2025 | 77% | 5% | 40% | 33% | 42% | 38% |

To simplify the use of this report, the calculation of delivery in percent of full Delta Table A is based on the maximum Delta Table A total of 4.133 maf for all five studies. The demands for studies 1 and 4 were developed assuming slightly earlier conditions when the maximum Delta Table A amounts totaled slightly less than 4.133 maf (4.114 maf and 4.112 maf, respectively). To show the effect of these minor differences in Table A totals, the annual deliveries in percent of full Delta Table A for study 1 (Table B-3) are calculated with the earlier Delta Table A total of 4.114 maf and also with the maximum Delta Table A total of 4.133 maf. Similarly, study 4 results in Table B-6 are calculated with the earlier and maximum Delta Table A totals. The tables show that most years have the same delivery percentage for both Table A totals.

These values must be interpreted within the confines of the assumptions upon which they are calculated. For example, for the year 1958 in study 5, the annual delivery is calculated to be 4,133 taf or 100 percent of maximum Delta Table A (see Table B-7). This result should be stated as follows:

If the rainfall were the same as it was in 1958 but (1) the level of water use in the source area was increased to the level it would be in 2025; (2) SWP facilities and operation requirements were the same as they are today; and (3) SWP contractor demands were at their maximum Delta Table A level, the SWP would deliver approximately 4,133 taf or 100 percent of the maximum Delta Table A.

Actually, the conditional statement associated with the result for any particular year is even more complicated than this because the result is also dependent upon the rainfall that has occurred in previous years. For example, if the previous year (1957) were wet, runoff for 1958 for the same amount of rainfall would be greater than if 1957 were dry. In addition, reservoir storage for the beginning of 1958 would vary depending upon the weather conditions in

1957. This linkage makes each year's simulation dependent on the previous year's and, hence, links the entire historical series.

Table B-2 contains a summary of the delivery estimates for the SWP for important dry periods in history computed by the studies. Studies 4 and 5 were selected to represent the estimated 2005 and 2025 deliveries, respectively. This information can be helpful in analyzing the delivery reliability of a specific water system that receives a portion of its water supply from the SWP. The series of data contained in Tables B-3 through B-7 are also helpful in analyzing longer periods of time that contain not only dry periods but wetter periods, which can replenish water supplies.

Finally, to help analyze the chance of receiving a given level of delivery in any particular year, a probability distribution curve is useful. It simply shows the percent of the years the annual delivery estimate is at or above a given value. The probability distribution curves for the five studies are included as figures B-1 and B-2. For example, for study 5 (Figure B-2), the curve indicates that in 75 percent of the years, the annual delivery reliability is estimated to be at or above 65 percent of the maximum Delta Table A amount or 2.70 maf. Similarly, annual delivery reliability during 50 percent of the years is estimated to be at or above 85 percent of the maximum Delta Table A or 3.50 maf. The curve also shows that in 25 percent of the years, annual delivery reliability is estimated to be at 100 percent of the maximum Delta Table A.





Table B-3 SWP water delivery from the Delta for Study 1 (taf)

| Year | Model variable Table A demand | Model Table A delivery | Percent of maximum Table A - 4.114 maf | Percent of future maximum Table A - 4.133 maf | Model Article 21 supply |
|---|---|---|---|---|---|
| 1922 | 3,407 | 3,389 | 82% | 82% | 175 |
| 1923 | 3,717 | 3,727 | 91% | 90% | 143 |
| 1924 | 3,961 | 1,014 | 25% | 25% | 0 |
| 1925 | 3,940 | 1,502 | 36% | 36% | 0 |
| 1926 | 3,777 | 2,951 | 72% | 71% | 0 |
| 1927 | 3,543 | 3,504 | 85% | 85% | 220 |
| 1928 | 3,897 | 3,337 | 81% | 81% | 155 |
| 1929 | 3,952 | 1,037 | 25% | 25% | 0 |
| 1930 | 3,922 | 2,697 | 66% | 65% | 92 |
| 1931 | 3,971 | 1,141 | 28% | 28% | 0 |
| 1932 | 3,673 | 1,620 | 39% | 39% | 199 |
| 1933 | 3,939 | 1,663 | 40% | 40% | 134 |
| 1934 | 3,981 | 1,689 | 41% | 41% | 0 |
| 1935 | 3,697 | 3,439 | 84% | 83% | 81 |
| 1936 | 3,769 | 3,638 | 88% | 88% | 0 |
| 1937 | 3,451 | 3,297 | 80% | 80% | 87 |
| 1938 | 3,418 | 3,439 | 84% | 83% | 470 |
| 1939 | 3,673 | 3,475 | 84% | 84% | 227 |
| 1940 | 3,713 | 3,544 | 86% | 86% | 102 |
| 1941 | 3,013 | 3,036 | 74% | 73% | 100 |
| 1942 | 3,583 | 3,599 | 87% | 87% | 513 |
| 1943 | 3,632 | 3,545 | 86% | 86% | 447 |
| 1944 | 3,563 | 3,449 | 84% | 83% | 0 |
| 1945 | 3,613 | 3,479 | 85% | 84% | 136 |
| 1946 | 3,710 | 3,724 | 91% | 90% | 3 |
| 1947 | 3,954 | 2,653 | 64% | 64% | 0 |
| 1948 | 3,959 | 2,681 | 65% | 65% | 2 |
| 1949 | 3,864 | 2,568 | 62% | 62% | 2 |
| 1950 | 3,812 | 2,909 | 71% | 70% | 0 |
| 1951 | 3,779 | 3,794 | 92% | 92% | 311 |
| 1952 | 3,078 | 3,108 | 76% | 75% | 103 |
| 1953 | 3,790 | 3,801 | 92% | 92% | 272 |
| 1954 | 3,833 | 3,803 | 92% | 92% | 98 |
| 1955 | 3,761 | 1,694 | 41% | 41% | 0 |
| 1956 | 3,639 | 3,649 | 89% | 88% | 261 |
| 1957 | 3,759 | 3,331 | 81% | 81% | 96 |
| 1958 | 3,481 | 3,492 | 85% | 84% | 441 |
| 1959 | 4,055 | 3,506 | 85% | 85% | 265 |
| 1960 | 4,114 | 1,795 | 44% | 43% | 0 |
| 1961 | 4,114 | 2,873 | 70% | 70% | 0 |
| 1962 | 3,689 | 3,158 | 77% | 76% | 21 |
| 1963 | 3,634 | 3,630 | 88% | 88% | 223 |
| 1964 | 3,907 | 3,262 | 79% | 79% | 5 |
| 1965 | 3,586 | 3,256 | 79% | 79% | 96 |
| 1966 | 3,722 | 3,731 | 91% | 90% | 147 |
| 1967 | 3,439 | 3,424 | 83% | 83% | 497 |
| 1968 | 3,792 | 3,548 | 86% | 86% | 402 |
| 1969 | 3,157 | 3,151 | 77% | 76% | 100 |
| 1970 | 3,714 | 3,727 | 91% | 90% | 406 |
| 1971 | 3,837 | 3,845 | 93% | 93% | 0 |
| 1972 | 4,012 | 3,057 | 74% | 74% | 2 |
| 1973 | 3,611 | 3,592 | 87% | 87% | 261 |
| 1974 | 3,650 | 3,664 | 89% | 88% | 297 |
| 1975 | 3,720 | 3,737 | 91% | 90% | 415 |
| 1976 | 4,014 | 3,150 | 77% | 76% | 110 |
| 1977 | 3,948 | 804 | 20% | 19% | 0 |
| 1978 | 3,126 | 3,036 | 74% | 73% | 100 |
| 1979 | 3,527 | 3,509 | 85% | 85% | 140 |
| 1980 | 3,197 | 3,208 | 78% | 78% | 100 |
| 1981 | 3,834 | 3,532 | 86% | 85% | 124 |
| 1982 | 3,451 | 3,471 | 84% | 84% | 366 |
| 1983 | 3,007 | 3,036 | 74% | 73% | 200 |
| 1984 | 3,692 | 3,706 | 90% | 90% | 408 |
| 1985 | 3,753 | 3,540 | 86% | 86% | 0 |
| 1986 | 3,345 | 3,023 | 73% | 73% | 51 |
| 1987 | 3,905 | 2,894 | 70% | 70% | 0 |
| 1988 | 4,026 | 968 | 24% | 23% | 0 |
| 1989 | 4,097 | 2,903 | 71% | 70% | 0 |
| 1990 | 3,961 | 1,101 | 27% | 27% | 0 |
| 1991 | 3,957 | 983 | 24% | 24% | 0 |
| 1992 | 3,880 | 1,199 | 29% | 29% | 0 |
| 1993 | 3,559 | 3,505 | 85% | 85% | 133 |
| 1994 | 3,739 | 3,272 | 80% | 79% | 9 |
| Average | 3,712 | 2,962 | 72% | 72% | 134 |
| Maximum | 4,114 | 3,845 | 93% | 93% | 513 |
| Minimum | 3,007 | 804 | 20% | 19% | 0 |

## Table B-4 SWP Water Delivery from the Delta for Study 2 (taf)

| Year | Model variable Table A demand | Model Table A delivery | Percent of maximum Table A - 4.133 maf | Model Article 21 supply |
|---|---|---|---|---|
| 1922 | 4,133 | 4,043 | 98% | 0 |
| 1923 | 4,133 | 3,670 | 89% | 0 |
| 1924 | 3,980 | 972 | 24% | 0 |
| 1925 | 4,133 | 1,445 | 35% | 0 |
| 1926 | 4,133 | 2,856 | 69% | 113 |
| 1927 | 4,133 | 4,032 | 98% | 124 |
| 1928 | 4,133 | 3,255 | 79% | 3 |
| 1929 | 3,971 | 1,070 | 26% | 0 |
| 1930 | 4,133 | 2,734 | 66% | 27 |
| 1931 | 4,133 | 1,086 | 26% | 0 |
| 1932 | 4,116 | 1,855 | 45% | 39 |
| 1933 | 4,133 | 1,966 | 48% | 6 |
| 1934 | 4,133 | 1,564 | 38% | 0 |
| 1935 | 3,907 | 3,562 | 86% | 59 |
| 1936 | 4,133 | 3,655 | 88% | 5 |
| 1937 | 4,133 | 3,189 | 77% | 65 |
| 1938 | 4,133 | 4,128 | 100% | 192 |
| 1939 | 3,948 | 3,443 | 83% | 1 |
| 1940 | 4,133 | 3,856 | 93% | 22 |
| 1941 | 3,481 | 3,472 | 84% | 0 |
| 1942 | 3,881 | 3,894 | 94% | 378 |
| 1943 | 4,120 | 3,591 | 87% | 375 |
| 1944 | 3,711 | 3,443 | 83% | 2 |
| 1945 | 3,948 | 3,574 | 86% | 123 |
| 1946 | 3,969 | 3,772 | 91% | 0 |
| 1947 | 3,973 | 2,602 | 63% | 0 |
| 1948 | 4,133 | 2,587 | 63% | 2 |
| 1949 | 3,996 | 2,656 | 64% | 0 |
| 1950 | 4,133 | 2,895 | 70% | 0 |
| 1951 | 4,094 | 3,994 | 97% | 230 |
| 1952 | 3,510 | 3,538 | 86% | 100 |
| 1953 | 4,063 | 3,989 | 97% | 236 |
| 1954 | 4,133 | 3,830 | 93% | 6 |
| 1955 | 3,995 | 1,735 | 42% | 0 |
| 1956 | 4,133 | 4,127 | 100% | 129 |
| 1957 | 4,029 | 3,069 | 74% | 3 |
| 1958 | 3,942 | 3,910 | 95% | 335 |
| 1959 | 4,133 | 3,477 | 84% | 167 |
| 1960 | 4,133 | 2,021 | 49% | 0 |
| 1961 | 4,133 | 2,815 | 68% | 0 |
| 1962 | 3,933 | 3,153 | 76% | 2 |
| 1963 | 4,133 | 4,046 | 98% | 134 |
| 1964 | 4,030 | 3,050 | 74% | 0 |
| 1965 | 3,966 | 3,234 | 78% | 3 |
| 1966 | 4,046 | 3,844 | 93% | 61 |
| 1967 | 4,033 | 3,979 | 96% | 167 |
| 1968 | 4,128 | 3,583 | 87% | 398 |
| 1969 | 3,583 | 3,556 | 86% | 93 |
| 1970 | 4,004 | 3,929 | 95% | 398 |
| 1971 | 4,133 | 4,082 | 99% | 0 |
| 1972 | 4,133 | 2,727 | 66% | 0 |
| 1973 | 4,119 | 3,699 | 89% | 211 |
| 1974 | 4,090 | 4,107 | 99% | 147 |
| 1975 | 4,113 | 4,088 | 99% | 209 |
| 1976 | 4,032 | 2,789 | 67% | 0 |
| 1977 | 4,133 | 830 | 20% | 0 |
| 1978 | 3,898 | 3,706 | 90% | 100 |
| 1979 | 4,133 | 3,512 | 85% | 89 |
| 1980 | 3,751 | 3,462 | 84% | 74 |
| 1981 | 4,133 | 3,400 | 82% | 0 |
| 1982 | 4,009 | 4,027 | 97% | 101 |
| 1983 | 3,343 | 3,370 | 82% | 200 |
| 1984 | 4,061 | 4,079 | 99% | 379 |
| 1985 | 3,905 | 3,326 | 80% | 0 |
| 1986 | 3,898 | 3,011 | 73% | 52 |
| 1987 | 3,923 | 2,837 | 69% | 0 |
| 1988 | 4,045 | 992 | 24% | 0 |
| 1989 | 4,133 | 2,895 | 70% | 0 |
| 1990 | 4,133 | 1,151 | 28% | 0 |
| 1991 | 4,133 | 999 | 24% | 0 |
| 1992 | 4,133 | 1,155 | 28% | 0 |
| 1993 | 4,133 | 4,018 | 97% | 156 |
| 1994 | 4,133 | 3,042 | 74% | 0 |
| Average | 4,026 | 3,083 | 75% | 78 |
| Maximum | 4,133 | 4,128 | 100% | 398 |
| Minimum | 3,343 | 830 | 20% | 0 |





## Table B-5 SWP Water Delivery from the Delta for Study 3 (taf)

| Year | Model fixed Table A demand | Model Table A delivery | Percent of maximum Table A - 4.133 maf | Model Article 21 supply |
|---|---|---|---|---|
| 1922 | 4,133 | 4,043 | 98% | 0 |
| 1923 | 4,133 | 3,670 | 89% | 0 |
| 1924 | 4,133 | 972 | 24% | 0 |
| 1925 | 4,133 | 1,446 | 35% | 0 |
| 1926 | 4,133 | 2,856 | 69% | 113 |
| 1927 | 4,133 | 4,031 | 98% | 124 |
| 1928 | 4,133 | 3,255 | 79% | 3 |
| 1929 | 4,133 | 1,070 | 26% | 0 |
| 1930 | 4,133 | 2,734 | 66% | 27 |
| 1931 | 4,133 | 1,086 | 26% | 0 |
| 1932 | 4,133 | 1,855 | 45% | 39 |
| 1933 | 4,133 | 1,967 | 48% | 6 |
| 1934 | 4,133 | 1,564 | 38% | 0 |
| 1935 | 4,133 | 3,729 | 90% | 59 |
| 1936 | 4,133 | 3,669 | 89% | 0 |
| 1937 | 4,133 | 3,165 | 77% | 71 |
| 1938 | 4,133 | 4,129 | 100% | 197 |
| 1939 | 4,133 | 3,444 | 83% | 1 |
| 1940 | 4,133 | 3,856 | 93% | 22 |
| 1941 | 4,133 | 4,084 | 99% | 0 |
| 1942 | 4,133 | 4,122 | 100% | 75 |
| 1943 | 4,133 | 3,584 | 87% | 318 |
| 1944 | 4,133 | 3,465 | 84% | 3 |
| 1945 | 4,133 | 3,547 | 86% | 123 |
| 1946 | 4,133 | 3,801 | 92% | 0 |
| 1947 | 4,133 | 2,597 | 63% | 0 |
| 1948 | 4,133 | 2,586 | 63% | 2 |
| 1949 | 4,133 | 2,654 | 64% | 0 |
| 1950 | 4,133 | 2,893 | 70% | 0 |
| 1951 | 4,133 | 3,996 | 97% | 222 |
| 1952 | 4,133 | 4,133 | 100% | 14 |
| 1953 | 4,133 | 3,931 | 95% | 244 |
| 1954 | 4,133 | 3,860 | 93% | 33 |
| 1955 | 4,133 | 1,779 | 43% | 0 |
| 1956 | 4,133 | 4,126 | 100% | 111 |
| 1957 | 4,133 | 3,067 | 74% | 3 |
| 1958 | 4,133 | 4,063 | 98% | 306 |
| 1959 | 4,133 | 3,467 | 84% | 97 |
| 1960 | 4,133 | 2,007 | 49% | 0 |
| 1961 | 4,133 | 2,818 | 68% | 0 |
| 1962 | 4,133 | 3,153 | 76% | 2 |
| 1963 | 4,133 | 4,046 | 98% | 134 |
| 1964 | 4,133 | 3,050 | 74% | 0 |
| 1965 | 4,133 | 3,233 | 78% | 3 |
| 1966 | 4,133 | 3,853 | 93% | 56 |
| 1967 | 4,133 | 4,069 | 98% | 115 |
| 1968 | 4,133 | 3,584 | 87% | 398 |
| 1969 | 4,133 | 4,078 | 99% | 13 |
| 1970 | 4,133 | 3,933 | 95% | 358 |
| 1971 | 4,133 | 4,082 | 99% | 0 |
| 1972 | 4,133 | 2,725 | 66% | 0 |
| 1973 | 4,133 | 3,699 | 89% | 211 |
| 1974 | 4,133 | 4,133 | 100% | 143 |
| 1975 | 4,133 | 4,102 | 99% | 211 |
| 1976 | 4,133 | 2,775 | 67% | 0 |
| 1977 | 4,133 | 830 | 20% | 0 |
| 1978 | 4,133 | 3,915 | 95% | 100 |
| 1979 | 4,133 | 3,493 | 85% | 98 |
| 1980 | 4,133 | 3,465 | 84% | 75 |
| 1981 | 4,133 | 3,387 | 82% | 0 |
| 1982 | 4,133 | 4,133 | 100% | 63 |
| 1983 | 4,133 | 4,133 | 100% | 160 |
| 1984 | 4,133 | 4,101 | 99% | 369 |
| 1985 | 4,133 | 3,322 | 80% | 0 |
| 1986 | 4,133 | 3,006 | 73% | 62 |
| 1987 | 4,133 | 2,835 | 69% | 0 |
| 1988 | 4,133 | 993 | 24% | 0 |
| 1989 | 4,133 | 2,895 | 70% | 0 |
| 1990 | 4,133 | 1,151 | 28% | 0 |
| 1991 | 4,133 | 999 | 24% | 0 |
| 1992 | 4,133 | 1,155 | 28% | 0 |
| 1993 | 4,133 | 4,018 | 97% | 156 |
| 1994 | 4,133 | 3,042 | 74% | 0 |
| Average | 4,133 | 3,130 | 76% | 68 |
| Maximum | 4,133 | 4,133 | 100% | 398 |
| Minimum | 4,133 | 830 | 20% | 0 |

## Table B-6 SWP water delivery from the Delta for Study 4 (taf)

| Year | Model variable Table A demand | Model Table A delivery | Percent of maximum Table A - 4.112 maf | Percent of future maximum Table A - 4.133 maf | Model Article 21 supply |
|---|---|---|---|---|---|
| 1922 | 3,750 | 3,743 | 91% | 91% | 104 |
| 1923 | 3,251 | 3,251 | 79% | 79% | 106 |
| 1924 | 3,489 | 1,244 | 30% | 30% | 0 |
| 1925 | 3,353 | 1,870 | 45% | 45% | 0 |
| 1926 | 3,393 | 2,981 | 72% | 72% | 54 |
| 1927 | 3,860 | 3,845 | 93% | 93% | 213 |
| 1928 | 3,458 | 3,384 | 82% | 82% | 134 |
| 1929 | 2,907 | 1,108 | 27% | 27% | 0 |
| 1930 | 3,326 | 2,855 | 69% | 69% | 117 |
| 1931 | 2,933 | 1,018 | 25% | 25% | 0 |
| 1932 | 3,139 | 1,406 | 34% | 34% | 242 |
| 1933 | 3,427 | 1,330 | 32% | 32% | 512 |
| 1934 | 3,470 | 1,541 | 37% | 37% | 206 |
| 1935 | 3,798 | 3,769 | 92% | 91% | 229 |
| 1936 | 3,596 | 3,573 | 87% | 86% | 0 |
| 1937 | 3,492 | 3,362 | 82% | 81% | 80 |
| 1938 | 3,344 | 3,344 | 81% | 81% | 714 |
| 1939 | 3,262 | 3,262 | 79% | 79% | 349 |
| 1940 | 3,239 | 3,219 | 78% | 78% | 154 |
| 1941 | 2,526 | 2,527 | 61% | 61% | 246 |
| 1942 | 3,167 | 3,167 | 77% | 77% | 918 |
| 1943 | 3,104 | 3,104 | 75% | 75% | 623 |
| 1944 | 3,090 | 3,091 | 75% | 75% | 0 |
| 1945 | 3,112 | 3,101 | 75% | 75% | 359 |
| 1946 | 3,215 | 3,215 | 78% | 78% | 249 |
| 1947 | 3,422 | 3,292 | 80% | 80% | 0 |
| 1948 | 3,395 | 2,942 | 72% | 71% | 0 |
| 1949 | 3,313 | 2,264 | 55% | 55% | 0 |
| 1950 | 3,465 | 3,199 | 78% | 77% | 0 |
| 1951 | 3,497 | 3,497 | 85% | 85% | 388 |
| 1952 | 2,585 | 2,588 | 63% | 63% | 275 |
| 1953 | 3,323 | 3,323 | 81% | 80% | 513 |
| 1954 | 3,294 | 3,294 | 80% | 80% | 523 |
| 1955 | 3,228 | 2,207 | 54% | 53% | 0 |
| 1956 | 3,581 | 3,586 | 87% | 87% | 324 |
| 1957 | 3,235 | 3,235 | 79% | 78% | 257 |
| 1958 | 2,980 | 2,980 | 72% | 72% | 1,106 |
| 1959 | 3,547 | 3,480 | 85% | 84% | 366 |
| 1960 | 3,555 | 1,865 | 45% | 45% | 0 |
| 1961 | 3,580 | 2,659 | 65% | 64% | 97 |
| 1962 | 3,690 | 3,262 | 79% | 79% | 0 |
| 1963 | 3,823 | 3,818 | 93% | 92% | 202 |
| 1964 | 3,492 | 3,323 | 81% | 80% | 0 |
| 1965 | 3,059 | 3,059 | 74% | 74% | 177 |
| 1966 | 3,282 | 3,282 | 80% | 79% | 518 |
| 1967 | 2,950 | 2,946 | 72% | 71% | 923 |
| 1968 | 3,324 | 3,329 | 81% | 81% | 552 |
| 1969 | 2,636 | 2,632 | 64% | 64% | 275 |
| 1970 | 3,257 | 3,257 | 79% | 79% | 552 |
| 1971 | 3,341 | 3,341 | 81% | 81% | 0 |
| 1972 | 3,457 | 3,342 | 81% | 81% | 414 |
| 1973 | 3,097 | 3,092 | 75% | 75% | 384 |
| 1974 | 3,184 | 3,184 | 77% | 77% | 854 |
| 1975 | 3,229 | 3,229 | 79% | 78% | 903 |
| 1976 | 3,471 | 3,265 | 79% | 79% | 189 |
| 1977 | 3,421 | 159 | 4% | 4% | 0 |
| 1978 | 3,623 | 3,603 | 88% | 87% | 300 |
| 1979 | 3,512 | 3,501 | 85% | 85% | 160 |
| 1980 | 2,715 | 2,709 | 66% | 66% | 138 |
| 1981 | 3,358 | 3,358 | 82% | 81% | 546 |
| 1982 | 2,890 | 2,890 | 70% | 70% | 801 |
| 1983 | 2,497 | 2,498 | 61% | 60% | 400 |
| 1984 | 3,227 | 2,766 | 67% | 67% | 552 |
| 1985 | 3,214 | 3,214 | 78% | 78% | 0 |
| 1986 | 2,321 | 2,297 | 56% | 56% | 120 |
| 1987 | 2,896 | 2,896 | 70% | 70% | 546 |
| 1988 | 2,967 | 856 | 21% | 21% | 0 |
| 1989 | 3,551 | 3,174 | 77% | 77% | 0 |
| 1990 | 3,628 | 1,099 | 27% | 27% | 0 |
| 1991 | 3,425 | 1,052 | 26% | 25% | 0 |
| 1992 | 3,366 | 1,426 | 35% | 34% | 0 |
| 1993 | 3,862 | 3,848 | 94% | 93% | 159 |
| 1994 | 3,689 | 3,306 | 80% | 80% | 0 |
| Average | 3,290 | 2,818 | 69% | 68% | 262 |
| Maximum | 3,862 | 3,848 | 94% | 93% | 1,106 |
| Minimum | 2,321 | 159 | 4% | 4% | 0 |





## Table B-7 SWP water delivery from the Delta for Study 5 (taf)

| Year | Model variable Table A demand | Model Table A delivery | Percent of maximum Table A -4.133 maf | Model Article 21 supply |
|---|---|---|---|---|
| 1922 | 4,133 | 4,133 | 100% | 21 |
| 1923 | 4,133 | 4,133 | 100% | 0 |
| 1924 | 4,133 | 382 | 9% | 0 |
| 1925 | 4,133 | 1,491 | 36% | 190 |
| 1926 | 4,133 | 2,721 | 66% | 279 |
| 1927 | 4,133 | 4,133 | 100% | 301 |
| 1928 | 4,133 | 3,379 | 82% | 0 |
| 1929 | 4,133 | 1,118 | 27% | 0 |
| 1930 | 4,133 | 2,738 | 66% | 141 |
| 1931 | 4,133 | 1,072 | 26% | 0 |
| 1932 | 4,133 | 1,572 | 38% | 112 |
| 1933 | 4,133 | 1,337 | 32% | 547 |
| 1934 | 4,133 | 1,471 | 36% | 242 |
| 1935 | 4,133 | 4,061 | 98% | 218 |
| 1936 | 4,133 | 3,729 | 90% | 0 |
| 1937 | 4,133 | 3,369 | 82% | 70 |
| 1938 | 4,133 | 4,133 | 100% | 200 |
| 1939 | 4,133 | 3,450 | 83% | 0 |
| 1940 | 4,133 | 4,116 | 100% | 114 |
| 1941 | 3,898 | 3,908 | 95% | 0 |
| 1942 | 4,133 | 4,133 | 100% | 123 |
| 1943 | 4,133 | 3,787 | 92% | 487 |
| 1944 | 4,133 | 3,542 | 86% | 0 |
| 1945 | 4,133 | 3,889 | 94% | 118 |
| 1946 | 4,133 | 3,828 | 93% | 0 |
| 1947 | 4,133 | 2,771 | 67% | 0 |
| 1948 | 4,133 | 2,940 | 71% | 0 |
| 1949 | 4,133 | 2,025 | 49% | 0 |
| 1950 | 4,133 | 3,400 | 82% | 0 |
| 1951 | 4,133 | 4,133 | 100% | 252 |
| 1952 | 3,898 | 3,912 | 95% | 0 |
| 1953 | 4,133 | 4,133 | 100% | 296 |
| 1954 | 4,133 | 4,133 | 100% | 0 |
| 1955 | 4,133 | 1,505 | 36% | 0 |
| 1956 | 4,133 | 4,133 | 100% | 352 |
| 1957 | 4,133 | 3,565 | 86% | 0 |
| 1958 | 4,133 | 4,133 | 100% | 229 |
| 1959 | 4,133 | 3,787 | 92% | 107 |
| 1960 | 4,133 | 1,607 | 39% | 0 |
| 1961 | 4,133 | 2,712 | 66% | 299 |
| 1962 | 4,133 | 3,311 | 80% | 1 |
| 1963 | 4,133 | 4,133 | 100% | 161 |
| 1964 | 4,133 | 2,889 | 70% | 0 |
| 1965 | 4,133 | 3,465 | 84% | 47 |
| 1966 | 4,133 | 4,133 | 100% | 178 |
| 1967 | 4,133 | 4,133 | 100% | 157 |
| 1968 | 4,133 | 3,797 | 92% | 465 |
| 1969 | 3,898 | 3,910 | 95% | 63 |
| 1970 | 4,133 | 4,122 | 100% | 493 |
| 1971 | 4,133 | 4,133 | 100% | 0 |
| 1972 | 4,133 | 2,721 | 66% | 0 |
| 1973 | 4,133 | 4,032 | 98% | 259 |
| 1974 | 4,133 | 4,133 | 100% | 69 |
| 1975 | 4,133 | 4,133 | 100% | 134 |
| 1976 | 4,133 | 3,137 | 76% | 0 |
| 1977 | 4,133 | 187 | 5% | 0 |
| 1978 | 3,898 | 3,902 | 94% | 300 |
| 1979 | 4,133 | 3,773 | 91% | 144 |
| 1980 | 3,898 | 3,513 | 85% | 86 |
| 1981 | 4,133 | 3,797 | 92% | 71 |
| 1982 | 4,133 | 4,133 | 100% | 171 |
| 1983 | 3,898 | 3,909 | 95% | 357 |
| 1984 | 4,133 | 4,133 | 100% | 490 |
| 1985 | 4,133 | 3,413 | 83% | 0 |
| 1986 | 3,898 | 2,857 | 69% | 83 |
| 1987 | 4,133 | 3,307 | 80% | 183 |
| 1988 | 4,133 | 423 | 10% | 0 |
| 1989 | 4,133 | 3,513 | 85% | 91 |
| 1990 | 4,133 | 855 | 21% | 0 |
| 1991 | 4,133 | 850 | 21% | 0 |
| 1992 | 4,133 | 1,461 | 35% | 102 |
| 1993 | 4,133 | 4,133 | 100% | 255 |
| 1994 | 4,133 | 3,153 | 76% | 0 |
| Average | 4,110 | 3,178 | 77% | 124 |
| Maximum | 4,133 | 4,133 | 100% | 547 |
| Minimum | 3,898 | 187 | 5% | 0 |

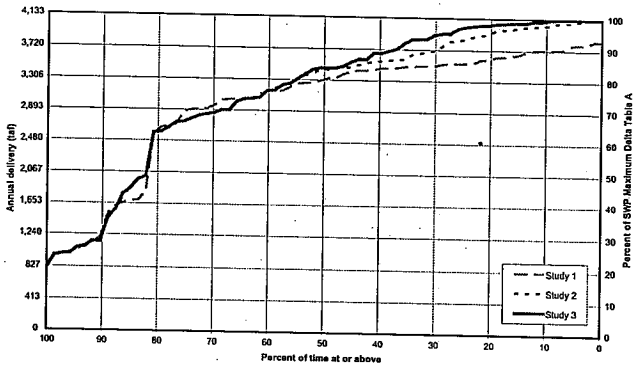


Figure B-1 SWP Delta Table A delivery probability for studies 1, 2 and 3

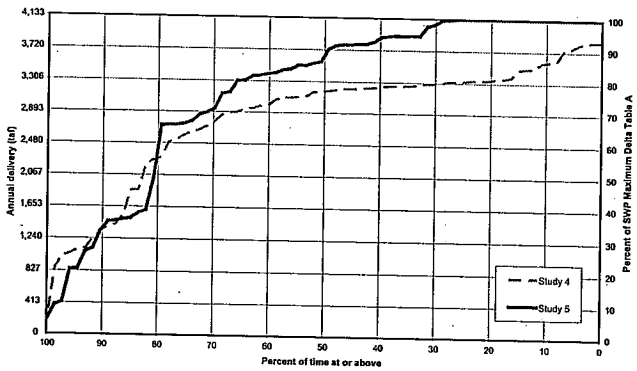


Figure B-2 SWP Delta Table A delivery probability for studies 4 and 5

# Appendix C. State Water Project Table A Amounts

## What is State Water Project Table A?

The contracts between the Department of Water Resources and the 29 State Water Project water contractors define the terms and conditions governing the water delivery and cost repayment for the SWP. Table A is an exhibit to these contracts. Comprehension of Table A is important in understanding the information in this report. To understand the table, it is necessary to understand how the contracts work.

All water-supply related costs of the SWP are paid by the contractors, and Table A serves as a basis for allocating some of the costs among the contractors. In addition, Table A plays a key role in the annual allocation of available supply among contractors. When the SWP was being planned, the amount of water projected to be available for delivery to the contractors was 4.2 million acre-feet (maf) per year. This was referred to as the minimum project yield, and it was recognized that in some years the project would be unable to deliver that amount and in other years project supply could exceed that amount. The 4.2 maf number was used as the basis for apportioning available supply to each contractor and as a factor in calculating each contractor's share of the project's costs. This apportionment is accomplished by Table A in each contract. Table A lists by year and acre-feet the portion of the 4.2 maf deliverable to each contractor. Other contract provisions permit changes to an individual contractor's Table A under special circumstances. The total of the maximums in all the contracts now equals 4.173 maf.

A copy of the consolidated Table A from all the contracts follows this explanation. The amounts listed in Table A cannot be viewed as an indication of the SWP water delivery reliability, nor should these amounts be used to support an expectation that a certain amount of water will be delivered to a contractor in any particular time span. Table A is simply a tool for apportioning available supply and cost obligations under the contract. In this report, reference to "Table A amounts" means the amounts listed in Table A. Contractors also receive other classifications of water from the project, as distinguished from Table A (for example, Article 21 water, and turnback pool water). These other contract provisions are discussed in Appendix D.





Table C-1 Maximum Annual SWP Table A Amounts

| SWP Contractors | Maximum Table A |
|---|---|
| **Delivered from the Delta** | |
| **North Bay** | |
| Napa County FC&WCD | 29,025 |
| Solano County WA | 47,756 |
| **Subtotal** | 76,781 |
| **South Bay** | |
| Alameda County FC&WCD, Zone 7 | 80,619 |
| Alameda County WD | 42,000 |
| Santa Clara Valley WD | 100,000 |
| **Subtotal** | 222,619 |
| **San Joaquin Valley** | |
| Oak Flat WD | 5,700 |
| County of Kings | 9,305 |
| Dudley Ridge WD | 57,343 |
| Empire West Side ID | 3,000 |
| Kern County WA | 998,730 |
| Tulare Lake Basin WSD | 95,922 |
| **Subtotal** | 1,170,000 |
| **Central Coastal** | |
| San Luis Obispo County FC&WCD | 25,000 |
| Santa Barbara County FC&WCD | 45,486 |
| **Subtotal** | 70,486 |
| **Southern California** | |
| Antelope Valley-East Kern WA | 141,400 |
| Castaic Lake WA | 95,200 |
| Coachella Valley WD | 121,100 |
| Crestline-Lake Arrowhead WA | 5,800 |
| Desert WA | 50,000 |
| Littlerock Creek ID | 2,300 |
| Mojave WA | 75,800 |
| Metropolitan WDSC | 1,911,500 |
| Palmdale WD | 21,300 |
| San Bernardino Valley MWD | 102,600 |
| San Gabriel Valley MWD | 28,800 |
| San Gorgonio Pass WA | 17,300 |
| Ventura County FCD | 20,000 |
| **Subtotal** | 2,593,100 |
| **Delta Subtotal** | 4,132,986 |
| **Feather River** | |
| County of Butte | 27,500 |
| Plumas County FC&WCD | 2,700 |
| City of Yuba City | 9,600 |
| **Subtotal** | 39,800 |
| **Grand Total** | 4,172,786 |

# Appendix D. Recent State Water Project Deliveries

## SWP Contract Water Types

The State Water Project contracts define several classifications of water available for delivery to contractors under specific circumstances. All classifications are considered "project" water. Many contractors make frequent use of these additional water types to increase or decrease the amount available to them under Table A.

### Table A Water

Each contract's Table A is the amount in acre-feet that is used to determine the portion of available supply to be delivered to that contractor. Table A water is water delivered according to this apportionment methodology and is given first priority for delivery.

### Article 21 Water

Article 21 of the contracts permits delivery of water excess to delivery of Table A and some other water types to those contractors requesting it. It is available under specific conditions discussed in Chapter 5. Article 21 water is apportioned to those contractors requesting it in the same proportion as their Table A.

### Turnback Pool Water

Contractors may choose to offer their allocated Table A water excess to their needs to other contractors through two pools in February and March. Contributing contractors receive a reduction in charges, and taking contractors pay extra.

### Carryover Water

Pursuant to the long-term water supply contracts, the Department of Water Resources (DWR) has offered contractors the opportunity to carry over a portion of their allocated water approved for delivery in the current year for delivery during the next year. The carryover program was designed to encourage the most effective and beneficial use of water and to avoid obligating the contractors to use or lose the water by December 31 of each year. The water supply contracts state the criteria of carrying over Table A water from one year to the next. Normally, carryover water is water that has been exported during the year, has not been delivered to the contractor during that year, and has remained stored in the SWP share of San Luis Reservoir to be delivered during the following year. Storage for carryover water no longer becomes available to the contractors if it interferes with storage of SWP water for project needs.

### Updated Historical Deliveries

The tables in this appendix list annual historical deliveries by various water classifications for each contractor for 1995 through 2004. Similar delivery tables for years 1995 through 2002 are included in the *State Water Project Delivery Reliability Report 2002*. Amounts listed for these years are slightly different due to accounting adjustments made by DWR's State Water Project Analysis Office.





Table D-1 Historical State Water Project Deliveries: 1995

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 203 | | | | 203 |
| Plumas County FC&WCD | 308 | | | | 308 |
| City of Yuba City | 910 | | | | 910 |
| Napa County FC&WCD | 5,182 | | | | 5,182 |
| Solano County WA | 21,345 | | | | 21,345 |
| Alameda County FC&WCD, Zone 7 | 30,091 | | | | 30,091 |
| Alameda County WD | 17,793 | | | | 17,793 |
| Santa Clara Valley WD | 28,756 | | | | 28,756 |
| Oak Flat WD | 5,169 | | | | 5,169 |
| County of Kings | 4,000 | | | | 4,000 |
| Dudley Ridge WD | 57,700 | | | 2,986 | 60,686 |
| Empire West Side ID | 957 | 106 | | 568 | 1,631 |
| Kern County WA | 1,089,063 | 59,671 | | 2,795 | 1,151,529 |
| Tulare Lake Basin WSD | 71,679 | 4,553 | | 25,637 | 101,869 |
| Antelope Valley-East Kern WA | 47,286 | | | | 47,286 |
| Castaic Lake WA (+Rch 31A, 5 & 7) | 25,660 | | | 1,573 | 27,233 |
| Coachella Valley WD | 23,100 | | | | 23,100 |
| Crestline-Lake Arrowhead WA | 409 | | | | 409 |
| Desert WA | 38,100 | | | | 38,100 |
| Littlerock Creek ID | 480 | | | | 480 |
| Mojave WA | 3,722 | | | | 3,722 |
| Metropolitan WDSC | 396,600 | | | 19,442 | 416,042 |
| Palmdale WD | 6,961 | | | | 6,961 |
| San Bernardino Valley MWD | 696 | | | | 696 |
| San Gabriel Valley MWD | 12,922 | | | | 12,922 |
| **Totals** | **1,889,092** | **64,330** | **0** | **53,001** | **2,006,423** |
| **Total South of Delta** | **1,887,671** | **64,330** | **0** | **53,001** | **2,005,002** |

## Table D-2 Historical State Water Project Deliveries: 1996

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 257 | | | | 257 |
| Plumas County FC&WCD | 360 | | | | 360 |
| City of Yuba City | 820 | | | | 820 |
| Napa County FC&WCD | 4,893 | | | | 4,893 |
| Solano County WA | 29,144 | | | 855 | 29,999 |
| Alameda County FC&WCD, Zone 7 | 18,903 | | | | 18,903 |
| Alameda County WD | 19,662 | | | | 19,662 |
| Santa Clara Valley WD | 88,829 | | | 1,021 | 89,850 |
| Oak Flat WD | 4,904 | | | | 4,904 |
| County of Kings | 4,000 | | | | 4,000 |
| Dudley Ridge WD | 52,491 | 4,457 | | | 56,948 |
| Empire West Side ID | 1,371 | | | 497 | 1,868 |
| Kern County WA | 1,117,060 | 15,653 | | 52,350 | 1,185,063 |
| Tulare Lake Basin WSD | 118,500 | 8,537 | 71,268 | 38,570 | 236,875 |
| San Luis Obispo County FC&WCD | 100 | | | | 100 |
| Antelope Valley-East Kern WA | 56,356 | | | | 56,356 |
| Castaic Lake WA (+Rch 31A, 5 & 7) | 32,500 | | | | 32,500 |
| Coachella Valley WD | 23,100 | | 39,119 | | 62,219 |
| Crestline-Lake Arrowhead WA | 485 | | | | 485 |
| Desert WA | 38,100 | | 64,522 | | 102,622 |
| Littlerock Creek ID | 494 | | | | 494 |
| Mojave WA | 7,427 | | | | 7,427 |
| Metropolitan WDSC | 553,259 | | | 40,121 | 593,380 |
| Palmdale WD | 11,434 | | | | 11,434 |
| San Bernardino Valley MWD | 6,064 | | | | 6,064 |
| San Gabriel Valley MWD | 15,989 | | | | 15,989 |
| Totals | 2,206,502 | 28,647 | 174,909 | 133,414 | 2,543,472 |
| Total South of Delta | 2,205,065 | 28,647 | 174,909 | 133,414 | 2,542,035 |





## Table D-3 Historical State Water Project Deliveries: 1997

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 185 | | | | 185 |
| Plumas County FC&WCD | 231 | | | | 231 |
| City of Yuba City | 1,005 | | | | 1,005 |
| Napa County FC&WCD | 4,341 | | | | 4,341 |
| Solano County WA | 35,530 | | | | 35,530 |
| Alameda County FC&WCD, Zone 7 | 27,522 | | | | 27,522 |
| Alameda County WD | 24,063 | | | | 24,063 |
| Santa Clara Valley WD | 95,601 | | | | 95,601 |
| Oak Flat WD | 5,238 | | | | 5,238 |
| Dudley Ridge WD | 51,623 | 7,141 | 12,544 | | 71,308 |
| Kern County WA | 1,092,543 | 10,264 | | | 1,102,807 |
| Tulare Lake Basin WSD | 21,156 | 1,213 | | | 22,369 |
| San Luis Obispo County FC&WCD | 1,199 | | | | 1,199 |
| Santa Barbara County FC&WCD | 7,439 | | | | 7,439 |
| Antelope Valley-East Kern WA | 61,752 | 641 | | | 62,393 |
| Castaic Lake WA (+Rch 31A, 5 & 7) | 27,712 | | | | 27,712 |
| Coachella Valley WD | 23,100 | | 35,000 | | 58,100 |
| Crestline-Lake Arrowhead WA | 651 | | | | 651 |
| Desert WA | 38,100 | | 15,000 | | 53,100 |
| Littlerock Creek ID | 444 | | | | 444 |
| Mojave WA | 10,374 | | | | 10,374 |
| Metropolitan WDSC | 738,990 | | | | 738,990 |
| Palmdale WD | 11,861 | | | | 11,861 |
| San Bernardino Valley MWD | 9,654 | | | | 9,654 |
| San Gabriel Valley MWD | 16,002 | 2,173 | | | 18,175 |
| Ventura County FCD | 1,850 | | | | 1,850 |
| Totals | 2,308,166 | 21,432 | 62,544 | 0 | 2,392,142 |
| Total South of Delta | 2,306,745 | 21,432 | 62,544 | 0 | 2,390,721 |

## Table D-4 Historical State Water Project Deliveries: 1998

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 527 | | | | 527 |
| City of Yuba City | 1,054 | | | | 1,054 |
| Napa County FC&WCD | 5,359 | | | | 5,359 |
| Solano County WA | 21,377 | 9,982 | | 407 | 31,766 |
| Alameda County FC&WCD, Zone 7 | 17,941 | | | | 17,941 |
| Alameda County WD | 19,075 | | | | 19,075 |
| Santa Clara Valley WD | 62,526 | | | 884 | 63,410 |
| Oak Flat WD | 4,401 | | | | 4,401 |
| County of Kings | 3 | 12 | | | 15 |
| Dudley Ridge WD | 52,919 | 984 | | 1,747 | 55,650 |
| Empire West Side ID | | | | 542 | 542 |
| Kern County WA | 856,906 | | | 1,684 | 858,590 |
| Tulare Lake Basin WSD | 11,367 | 9,310 | | | 20,677 |
| San Luis Obispo County FC&WCD | 3,592 | | | | 3,592 |
| Santa Barbara County FC&WCD | 18,618 | | | | 18,618 |
| Antelope Valley-East Kern WA | 52,926 | | | | 52,926 |
| Castaic Lake WA (+Rch 31A, 5 & 7) | 20,093 | | | | 20,093 |
| Coachella Valley WD | 23,100 | | 55,000 | | 78,100 |
| Crestline-Lake Arrowhead WA | 187 | | | | 187 |
| Desert WA | 38,100 | | 20,000 | | 58,100 |
| Littlerock Creek ID | 404 | | | | 404 |
| Mojave WA | 3,925 | | | | 3,925 |
| Metropolitan WDSC | 359,213 | | | 33,672 | 392,885 |
| Palmdale WD | 8,752 | | | | 8,752 |
| San Bernardino Valley MWD | 1,878 | | | | 1,878 |
| San Gabriel Valley MWD | 9,310 | | | | 9,310 |
| Ventura County FCD | 1,850 | | | | 1,850 |
| **Totals** | **1,595,403** | **20,288** | **75,000** | **38,936** | **1,729,627** |
| **Total South of Delta** | **1,593,822** | **20,288** | **75,000** | **38,936** | **1,728,046** |





## Table D-5 Historical State Water Project Deliveries: 1999

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 286 | | | | 286 |
| City of Yuba City | 1,096 | | | | 1,096 |
| Napa County FC&WCD | 4,550 | 754 | | | 5,304 |
| Solano County WA | 37,753 | | | | 37,753 |
| Alameda County FC&WCD, Zone 7 | 46,000 | 2,910 | | | 48,910 |
| Alameda County WD | 34,871 | 2,781 | | | 37,652 |
| Santa Clara Valley WD | 67,465 | 15,480 | | | 82,945 |
| Oak Flat WD | 4,871 | | | | 4,871 |
| County of Kings | 4,000 | | | | 4,000 |
| Dudley Ridge WD | 51,870 | 4,990 | 6,566 | | 63,426 |
| Empire West Side ID | 3,000 | 176 | | | 3,176 |
| Kern County WA | 1,077,755 | 58,241 | 42,154 | | 1,178,150 |
| Tulare Lake Basin WSD | 118,500 | 49,898 | 121,337 | | 289,735 |
| San Luis Obispo County FC&WCD | 3,743 | | | | 3,743 |
| Santa Barbara County FC&WCD | 20,137 | | | | 20,137 |
| Antelope Valley-East Kern WA | 69,073 | | | | 69,073 |
| Castaic Lake WA (+Rch 31A, 5 & 7) | 32,899 | | | | 32,899 |
| Coachella Valley WD | 23,100 | | 27,380 | | 50,480 |
| Crestline-Lake Arrowhead WA | 1,132 | | | | 1,132 |
| Desert WA | 38,100 | | 20,000 | | 58,100 |
| Littlerock Creek ID | 342 | | | | 342 |
| Mojave WA | 5,144 | | | | 5,144 |
| Metropolitan WDSC | 829,777 | 22,840 | | | 852,617 |
| Palmdale WD | 13,278 | | | | 13,278 |
| San Bernardino Valley MWD | 12,874 | | | | 12,874 |
| San Gabriel Valley MWD | 18,000 | | | | 18,000 |
| Ventura County FCD | 1,850 | | | | 1,850 |
| **Totals** | **2,521,466** | **158,070** | **217,437** | **0** | **2,896,973** |
| **Total South of Delta** | **2,520,084** | **158,070** | **217,437** | **0** | **2,895,591** |

## Table D-6 Historical State Water Project Deliveries: 2000

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 586 | | | | 586 |
| City of Yuba City | 901 | | | | 901 |
| Napa County FC&WCD | 3,136 | 297 | | 1,525 | 4,958 |
| Solano County WA | 32,882 | 1,040 | | 1,417 | 35,339 |
| Alameda County FC&WCD, Zone 7 | 53,877 | 3,740 | | | 57,617 |
| Alameda County WD | 33,598 | 2,380 | | | 35,978 |
| Santa Clara Valley WD | 70,433 | 18,381 | | 13,174 | 101,988 |
| Oak Flat WD | 4,494 | | | 14 | 4,508 |
| County of Kings | 3,600 | | | | 3,600 |
| Dudley Ridge WD | 38,673 | 7,454 | 12,193 | 2,884 | 61,204 |
| Empire West Side ID | 1,271 | 528 | | | 1,799 |
| Kern County WA | 825,856 | 78,908 | 233,202 | 13,193 | 1,151,159 |
| Tulare Lake Basin WSD | 98,595 | 56,818 | 27,073 | 15,827 | 198,313 |
| San Luis Obispo County FC&WCD | 3,962 | | | | 3,962 |
| Santa Barbara County FC&WCD | 22,741 | | | | 22,741 |
| Antelope Valley-East Kern WA | 83,577 | | | | 83,577 |
| Castaic Lake WA (+Rch 31A, 5 & 7) | 40,680 | | | | 40,680 |
| Coachella Valley WD | 20,790 | 17,820 | 3,713 | | 42,323 |
| Crestline-Lake Arrowhead WA | 1,194 | | | | 1,194 |
| Desert WA | 34,290 | 17,820 | 6,124 | | 58,234 |
| Mojave WA | 9,135 | | | | 9,135 |
| Metropolitan WDSC | 1,273,729 | 103,124 | | 169,529 | 1,546,382 |
| Palmdale WD | 8,221 | | | 839 | 9,060 |
| San Bernardino Valley MWD | 18,399 | | | | 18,399 |
| San Gabriel Valley MWD | 14,000 | 475 | | | 14,475 |
| Ventura County FCD | 4,050 | | | | 4,050 |
| **Totals** | **,702,670** | **308,785** | **282,305** | **218,402** | **3,512,162** |
| **Total South of Delta** | **2,701,183** | **308,785** | **282,305** | **218,402** | **3,510,675** |





## Table D-7 Historical State Water Project Deliveries: 2001

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 513 | | | | 513 |
| City of Yuba City | 1,065 | | | | 1,065 |
| Napa County FC&WCD | 4,293 | 996 | 82 | 1,723 | 7,094 |
| Solano County WA | 17,756 | 2,304 | | 1,021 | 21,081 |
| Alameda County FC&WCD, Zone 7 | 22,307 | | 308 | 5,990 | 28,605 |
| Alameda County WD | 13,695 | 10 | 107 | 4,192 | 18,004 |
| Santa Clara Valley WD | 35,689 | | | 12,233 | 47,922 |
| Oak Flat WD | 2,089 | | 22 | 101 | 2,212 |
| County of Kings | 1,560 | | | | 1,560 |
| Dudley Ridge WD | 18,467 | 933 | 347 | 6,815 | 26,562 |
| Empire West Side ID | | 253 | | 1,107 | 1,360 |
| Kern County WA | 363,204 | 23,233 | 6,502 | 92,052 | 484,991 |
| Tulare Lake Basin WSD | 40,830 | 8,755 | 769 | 7,889 | 58,243 |
| San Luis Obispo County FC&WCD | 4,184 | | 99 | | 4,283 |
| Santa Barbara County FC&WCD | 14,285 | 396 | 296 | | 14,977 |
| Antelope Valley-East Kern WA | 45,071 | | 899 | | 45,970 |
| Castaic Lake WA (+Rch 31A, 5 & 7) | 30,471 | 850 | 618 | | 31,939 |
| Coachella Valley WD | 9,009 | | 91 | | 9,100 |
| Crestline-Lake Arrowhead WA | 1,057 | | | | 1,057 |
| Desert WA | 14,859 | | 151 | | 15,010 |
| Mojave WA | 4,433 | | | | 4,433 |
| Metropolitan WDSC | 686,545 | 10,415 | 7,949 | 200,000 | 904,909 |
| Palmdale WD | 8,170 | | | 2,257 | 10,427 |
| San Bernardino Valley MWD | 26,488 | | | | 26,488 |
| San Gabriel Valley MWD | 6,534 | | | | 6,534 |
| Ventura County FCD | 1,850 | | | | 1,850 |
| **Totals** | **1,374,424** | **48,145** | **18,240** | **335,380** | **1,776,189** |
| **Total South of Delta** | **1,372,846** | **48,145** | **18,240** | **335,380** | **1,774,611** |

Table D-8 Historical State Water Project Deliveries: 2002

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 419 | | | | 419 |
| City of Yuba City | 1,181 | | | | 1,181 |
| Napa County FC&WCD | 2,022 | 827 | 283 | 3,743 | 6,875 |
| Solano County WA | 28,223 | 2,242 | | | 30,465 |
| Alameda County FC&WCD, Zone 7 | 40,707 | 1,484 | 556 | 8,113 | 50,860 |
| Alameda County WD | 24,250 | 83 | 862 | 2,331 | 27,526 |
| Santa Clara Valley WD | 55,896 | 202 | 2,053 | 3,311 | 61,462 |
| Oak Flat WD | 3,841 | 50 | 76 | 134 | 4,101 |
| County of Kings | 2,800 | | 54 | | 2,854 |
| Dudley Ridge WD | 38,688 | 1,861 | 1,177 | 1,994 | 43,720 |
| Empire West Side ID | 1,278 | 26 | | 101 | 1,405 |
| Kern County WA | 670,884 | 21,951 | 20,543 | 15,680 | 729,058 |
| Tulare Lake Basin WSD | 73,785 | 3,749 | 2,289 | 5,385 | 85,208 |
| San Luis Obispo County FC&WCD | 4,355 | | | | 4,355 |
| Santa Barbara County FC&WCD | 24,166 | 436 | 324 | 3,455 | 28,381 |
| Antelope Valley-East Kern WA | 53,907 | | 1,008 | 3,256 | 58,171 |
| Castaic Lake WA (+Rch 31A, 5 & 7) | 61,880 | 280 | | 6,657 | 68,817 |
| Coachella Valley WD | 16,170 | 111 | 474 | | 16,755 |
| Crestline-Lake Arrowhead WA | 2,189 | | | | 2,189 |
| Desert WA | 26,670 | 189 | 781 | | 27,640 |
| Mojave WA | 4,346 | | | | 4,346 |
| Metropolitan WDSC | 1,273,205 | 9,624 | 14,335 | 97,940 | 1,395,104 |
| Palmdale WD | 8,359 | | 437 | | 8,796 |
| San Bernardino Valley MWD | 68,268 | | | 3,801 | 72,069 |
| San Gabriel Valley MWD | 18,353 | | | 4,698 | 23,051 |
| Ventura County FCD | 4,998 | | | | 4,998 |
| Totals | 2,510,840 | 43,115 | 45,252 | 160,599 | 2,759,806 |
| Total South of Delta | 2,509,240 | 43,115 | 45,252 | 160,599 | 2,758,206 |





Table D-9 Historical State Water Project Deliveries: 2003

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 551 | | | | 551 |
| City of Yuba City | 1,324 | | | | 1,324 |
| Napa County FC&WCD | 6,026 | 376 | 180 | 1,055 | 7,637 |
| Solano County WA | 25,135 | 2,280 | | 1,918 | 29,333 |
| Alameda County FC&WCD, Zone 7 | 30,695 | | 656 | 13,099 | 44,450 |
| Alameda County WD | 31,086 | | 354 | 5,150 | 36,590 |
| Santa Clara Valley WD | 90,620 | 936 | 841 | 14,104 | 106,501 |
| Oak Flat WD | 4,059 | 19 | 48 | 140 | 4,266 |
| County of Kings | 3,600 | 58 | 34 | | 3,692 |
| Dudley Ridge WD | 49,723 | 1,928 | 482 | 1,452 | 53,585 |
| Empire West Side ID | 1,074 | 175 | | 187 | 1,436 |
| Kern County WA | 841,697 | 27,891 | 8,419 | 22,380 | 900,387 |
| Tulare Lake Basin WSD | 94,376 | 6,243 | 938 | 4,284 | 105,841 |
| San Luis Obispo County FC&WCD | 4,417 | 36 | | | 4,453 |
| Santa Barbara County FC&WCD | 24,312 | 339 | 43 | 2,274 | 26,968 |
| Antelope Valley-East Kern WA | 52,730 | | 250 | 7,049 | 60,029 |
| Castaic Lake WA (+Rch 31A, 5 & 7) | 49,895 | 991 | 90 | 4,760 | 55,736 |
| Coachella Valley WD | 14,045 | 204 | 194 | | 14,443 |
| Crestline-Lake Arrowhead WA | 1,563 | | | | 1,563 |
| Desert WA | 23,168 | 330 | 321 | | 23,819 |
| Mojave WA | 10,907 | | | 3,528 | 14,435 |
| Metropolitan WDSC | 1,550,356 | 17,622 | 16,920 | 134,845 | 1,719,743 |
| Palmdale WD | 9,701 | | | 1,846 | 11,547 |
| San Bernardino Valley MWD | 25,371 | 200 | | 1,844 | 27,415 |
| San Gabriel Valley MWD | 13,034 | 200 | | | 13,234 |
| San Gorgonio Pass WA | 116 | | | | 116 |
| Ventura County FCD | 5,000 | | | | 5,000 |
| Totals | 2,964,581 | 59,828 | 29,770 | 219,915 | 3,274,094 |
| Total South of Delta | 2,962,706 | 59,828 | 29,770 | 219,915 | 3,272,219 |

Table D-10 Historical State Water Project Deliveries: 2004

| | Table A | Art. 21 | Turnback | Carryover | Total |
|---|---|---|---|---|---|
| County of Butte | 1,440 | | | | 1,440 |
| City of Yuba City | 1,434 | | | | 1,434 |
| Napa County FC&WCD | 5,030 | 1,450 | 52 | 1,602 | 8,134 |
| Solano County WA | 15,991 | 7,787 | | 47 | 23,825 |
| Alameda County FC&WCD, Zone 7 | 38,895 | | | 11,466 | 50,361 |
| Alameda County WD | 20,959 | | 214 | 6,714 | 27,887 |
| Santa Clara Valley WD | 52,867 | 2,983 | 508 | | 56,358 |
| Oak Flat WD | 4,324 | | 29 | 276 | 4,629 |
| County of Kings | 5,850 | 3,157 | 46 | | 9,053 |
| Dudley Ridge WD | 36,676 | 7,393 | 291 | 1,886 | 46,246 |
| Empire West Side ID | 1,310 | 626 | | 1,626 | 3,562 |
| Kern County WA | 641,368 | 86,513 | 5,075 | 38,729 | 771,685 |
| Tulare Lake Basin WSD | 58,125 | 15,299 | 489 | 5,638 | 79,551 |
| San Luis Obispo County FC&WCD | 4,096 | 69 | | | 4,165 |
| Santa Barbara County FC&WCD | 29,358 | | 122 | | 29,480 |
| Antelope Valley-East Kern WA | 50,532 | | | 9,199 | 59,731 |
| Castaic Lake WA (+Reh 31A, 5 & 7) | 46,358 | 1,618 | | 35,785 | 83,761 |
| Coachella Valley WD | 8,631 | | 89 | 6,745 | 15,465 |
| Crestline-Lake Arrowhead WA | 2,006 | | | | 2,006 |
| Desert WA | 9,966 | | 102 | 11,122 | 21,190 |
| Mojave WA | 13,176 | | | | 13,176 |
| Metropolitan WDSC | 1,195,807 | 91,601 | 10,223 | 215,000 | 1,512,631 |
| Palmdale WD | 10,549 | | | 1,613 | 12,162 |
| San Bernardino Valley MWD | 35,523 | | | 20,631 | 56,154 |
| San Gabriel Valley MWD | 15,600 | | | | 15,600 |
| San Gorgonio Pass WA | 837 | | | | 837 |
| Ventura County FCD | 5,250 | | | | 5,250 |
| Totals | 2,311,958 | 218,496 | 17,240 | 368,079 | 2,915,773 |
| Total South of Delta | 2,309,084 | 218,496 | 17,240 | 368,079 | 2,912,899 |

# Appendix E. Technical Memorandum Report Summaries: Historical SWP/CVP Operations Simulation and CalSim II Model Sensitivity Analysis

## Study

This appendix presents summaries of the findings of the CalSim II Simulation of Historical SWP/CVP Operations and a CalSim II Model Sensitivity Analysis Study. The entire reports are available at the websites listed at the end of this appendix.

## 1. CalSim II Simulation of Historical SWP/CVP Operations

### Technical Memorandum Report

#### Objective of Study

The purpose of the Historical Operations Study is to evaluate the ability of CalSim II to represent CVP and SWP operations, in general, and the delivery capability of the projects, in particular, through the monthly simulation of recent historical conditions.

#### Study Description

The period of simulation for the Historical Operations Study is water years 1975 to 1998. This 24-year period includes the 1976-77 and 1987-92 droughts, as well as the driest (1977) and the wettest (1983) years on record. The version of CalSim II used for this study is the benchmark study dated 30 September 2002, but with some inputs changed to reflect the historically changing conditions rather than a fixed level of development. Model inflows correspond to the historical flow from gage records, or are estimated from a hydrologic mass balance, or stream-flow correlation. Land use-based demands are calculated for annual varying land use, as determined from DWR's land surveys and county commissioners' reports. The operational logic has been revised to reflect the changing regulatory environment. The historical regulations have been simplified into three periods:

- October 1974–September 1992: represented by State Water Resources Control Board (SWRCB) Water Right Decision 1485 (D-1485),
- October 1992–September 1994: represented by D-1485 and the 1993 National Marine Fisheries Service (NMFS) winter-run Chinook salmon biological opinion (minimum carryover storage in Lake Shasta, and temperature related minimum instream flows downstream of Keswick Reservoir),
- October 1994–September 1998: represented by SWRCB Water Right Decision 1641 (D-1641) and the 1993 winter-run biological opinion.

The Historical Operations Study is limited in geographical scope to a dynamic operation of the Sacramento Valley, the Delta, and the CVP-SWP facilities south of the Delta. Delta inflows from the San Joaquin Valley and East Side streams are constrained to their historical values. Imports from the Trinity River system are similarly constrained.

#### Results and Discussion

The key performance measures in evaluating CalSim II are considered to be SWP and CVP deliveries, project storage operations, and stream flows. During the study period of water years 1975-1998, SWP demands were historically much lower than the current or projected level of demands. Simulation of historically wet years, when the system was not supply constrained,





may therefore be a poor indicator of the model's ability to accurately simulate future levels of development. Particular attention is therefore placed on model results during the six-year drought of 1987-1992. Results for four key performance parameters are summarized in the table below.

The table below shows that simulated SWP Table A and CVP south-of-Delta deliveries during the drought are less than historical values. Differences are, however, within 5 percent. Comparison of Sacramento Valley inflow to the Delta (flow at Freeport) is a good measure of how well the Sacramento Valley hydrology is simulated by CalSim II. Simulated Delta inflows are 0.3 percent greater than historical. Comparison of the Net Delta Outflow Index, a measure of how well the Sacramento-San Joaquin Delta is represented by CalSim II, appears favorable. Simulated values are 3.5 percent greater than historical during the 1987-1992 period. The table also shows that simulated long-term (1975-1998) average deliveries compare quite well and are within 7 percent of historical values.

The total volume of surface water to be held in storage or routed through the model network is the same as historical. Model inflows to the Delta can deviate from historical due to three reasons: storage regulation, groundwater pumping to supplement surface water diversions, and stream-aquifer interaction.

Differences in Delta inflows are primarily caused by differences in project storage regulation (i.e. Lake Shasta, Lake Oroville and Folsom Lake). Storage operations in CalSim II are driven by two sets of rule curves. The first set of rule curves determines how much of the available project water will be held as carryover storage and how much will be delivered to meet contractors' current-year demands. The second set of rule curves determines when and how-much water will be transferred from north of Delta storage to San Luis Reservoir. These two sets of rule curves are fixed throughout the period of simulation. The rule curves have been determined in prior simulations of CalSim II. They are subjective in nature, but balance the conflicting objectives to maximize long-term average annual deliveries, to maintain water deliveries during the critically dry period 1928-34, and to keep water levels in project reservoirs above minimum levels while meeting minimum flow requirements. Secondly, differences in Delta inflows are due to differences in upstream surface water diversions and return flows. The historical consumptive water demand must be met by the model. Differences in Delta inflow, after accounting for differences in upstream storage regulation, therefore reveal how well CalSim II matches the historical mix of surface water and groundwater to meet demands. Lastly inflows to the Delta are influenced by the stream-aquifer interaction.

For a given south-of-Delta demand and a given Delta inflow, differences in model and historical project exports are indicative of how well the model represents the regulatory operating constraints to which the projects must comply, and how the model simulates storage operations in the San Luis Reservoir.

Conclusions from the study can be framed in the form of answers to some frequently asked questions about CalSim II.

***Does CalSim II overestimate the projects' ability to export water from the Delta?***

For the supply constrained years 1987-1992, model exports from the Delta average 4,450 taf/yr compared to a historical six-year average of 4,460 taf/yr. This suggests that CalSim II's

| | Dry-period average 1987-1992 | | | | Long-term average | | | |
|---|---|---|---|---|---|---|---|---|
| | Simulated | Historical | Difference | | Simulated | Historical | Difference | |
| Performance parameter | taf/yr | | | % | taf/yr | | | % |
| SWP south-of-Delta Table A deliveries | 1,930 | 2,030 | -100 | -4.9 | 1,810 | 1,790 | 20 | 1.1 |
| CVP south-of-Delta deliveries | 2,230 | 2,320 | -90 | -3.9 | 2,650 | 2,490 | 160 | 6.4 |
| Sacramento Valley inflow to the Delta | 9,700 | 9,670 | 30 | 0.3 | 19,830 | 19,920 | -90 | -0.5 |
| Net Delta Outflow Index | 5,270 | 5,090 | 180 | 3.5 | 19,070 | 19,690 | -620 | -3.1 |

simulation of the Delta operations is representative of actual historical conditions.

*Does CalSim II overestimate the availability of surface water in the Delta by meeting Sacramento Valley in-basin use through excessive groundwater pumping?*

The mix of surface water and groundwater used by the model to meet Sacramento Valley consumptive demands depends primarily on project water allocation decisions and levels of minimum groundwater pumping that are specified in the model. Over the 24-year period average annual net groundwater extraction in CalSim II as compared to estimates based on the Central Valley Groundwater Surface water Model (CVGSM) is lower by 378 taf. The average annual net stream inflow from groundwater in CalSim II is 190 taf greater than estimated by the CVGSM for the same period. The combined effect of dynamically modeling groundwater operations in CalSim II (pumping, recharge and stream-aquifer interaction) leads to 188 taf/yr less water being available to the Delta. For the 1987-1992 period the combined effect results in 46 taf/yr additional water being available to the Delta.

*How well does CalSim II represent stream flows?*

Differences in long-term average annual flows at key stream locations are typically 1.2 percent or less. It is noted that differences are larger for the Sacramento River at the Ord Ferry gage. At this location a proportion of the water diverted upstream returns downstream so that simulated river flows are sensitive to assumed model water use efficiencies.

*How well does CalSim II simulate the Sacramento Valley system?*

The net Sacramento Valley accretion is calculated as the Sacramento Valley Delta inflow less releases from Whiskeytown Reservoir, Keswick Reservoir, Lake Oroville and Folsom Lake. The historical 24-year average annual net accretion is 5,950 taf/yr compared with a model value of 5,920 taf/yr.

*Do different reservoir operating rules in CalSim II translate into differences in project deliveries?*

Simulated month-to-month and year-to-year model results can vary significantly from historical operations. This is primarily due to differences in storage operations. However when averaged over a longer period, model operations (stream flows and deliveries) are very close to historical.

## 2. CalSim II Model Sensitivity Analysis Study Technical Memorandum Report

### Background

The sensitivity analysis is an important component of any water resources planning model evaluation. It enhances understanding of the model, builds greater public confidence, and expands public acceptance of the model. The sensitivity analysis explores and quantifies the effects of various inputs on the model outputs. With a simple sensitivity analysis procedure, variations of model input parameters are generally investigated one at a time. With a more complex procedure, the investigation is conducted by changing a set of input parameters simultaneously. For this study, the simple sensitivity study procedure is used.

The Sensitivity Analysis Study responds to the commitment in *The State Water Project Delivery Reliability Report 2002* to conduct such a study and to issues raised during the public review of that report. The sensitivity analysis study is also one of the recommendations by the CalSim II peer review sponsored by the CALFED Science Program in December 2003. The review panel recommended such a study would help identify key input parameters that have significant effects on the model output, and to provide a systematic way to measure the sensitivity of the model output to variations of key input parameters.

### Study Objectives

There are three objectives of the CalSim II Sensitivity Analysis Study:

- to examine the behavior of the SWP-CVP system performance in response to variations in selected input parameters within CalSim-II
- to help SWP contractors and others understand the impact of key assumptions within CalSim II on the SWP delivery capability
- to aid CalSim II modelers for prioritizing future model development activities on the basis of sensitivities of input parameters

## Study Description

The development of the CalSim II model is an ongoing effort. DWR and Reclamation periodically release updated versions of the model. This study uses the modified benchmark study of September 30, 2002, under the D-1641 regulatory environment as the base study.

The CalSim II model uses many input parameters to define the physical characteristics of the system, as well as the regulatory environment and operational parameters. Input parameters include time series, single dimensionless coefficients, or monthly distribution curves. Some input parameters are estimated from the historical data and others are user-input or calibrated values. After discussions with model developers and project operators, 21 model input parameters in four major categories and their reasonable ranges of variations were selected for this study. Similarly, there are many output variables in different categories, including reservoir storage, flows at key locations, Delta outflows, project exports and deliveries that characterize the overall outcome of any particular simulation run. After discussions with model users, project operators, and model developers, 22 key output variables that cover various aspects of the SWP-CVP system performance were selected.

In this study, two performance measures – Sensitivity Index (SI) and Elasticity Index (EI) – are used to quantify the model output sensitivity with respect to a certain model input parameter. The SI is a first-order derivative of a model output variable with respect to an input parameter. It can be used to measure the magnitude of change in an output variable per unit change in the magnitude of an input parameter from its base value. The EI is a dimensionless expression of sensitivity that measures the relative change in an output variable to a relative change in an input parameter. As an example, assuming SI = 0.5 and EI = 0.25 for the output variable of total Delta outflow with respect to the input parameter of Oroville inflow, means that for one thousand acre-feet (taf) increase in Oroville inflow, total Delta outflow increases by 0.5 taf; and for 1 percent increase in Oroville inflow, total Delta outflow increases by 0.25 percent, respectively.

### Study Results and Discussions

The complete results of the study showing sensitivity and elasticity indices for each one of the selected output variables are listed in terms of their long-term (1922–1994) averages with respect to variations of input parameters. Table E-1 highlights the behavior of some of the key output variables that define the important aspects of SWP–CVP system performance. In Table E-1, the top row is the list of model input parameters and the left-most column is the list of model output variables. In general, each cell in the table contains two numbers except cells in Columns 8 and 9. The number inside parentheses is the SI value and the number outside parentheses is the EI value. Signs in front of SI and EI values can be either positive or negative. In general, the positive sign indicates that the output variable changes in the same direction as the input parameter. For example, as shown in the Row 1 of Column 1 in the table, when SWP Table A demand increases, SWP total delivery, which is the sum of SWP Delta delivery and FRSA delivery, increases as well (SI = +0.39). SWP Delta Delivery is defined as SWP Table A deliveries to South-of-Delta plus deliveries to North Bay (Solano and Napa Counties) contractors. FRSA delivery is defined as the sum of deliveries to the Settlement Contractors in Feather River Service Area (FRSA) and Table A deliveries to Butte and Yuba Counties. The negative sign indicates that the output variable changes in the opposite direction as the input parameter. For example, as shown in the Row 5 of Column 1 in the table, when SWP Table A demand increases, Article 21 delivery decreases (SI = -0.13). In order to highlight relative sensitivity of the various input parameters, a color coded cell background has been used. A red color cell background represents a relatively higher sensitivity or (SI >= 0.2); yellow background represents a moderate sensitivity or (0.1 <= SI <= 0.2); and white background shows a lower sensitivity or (SI <= 0.1).

Table E-1 Summary excerpt of Elasticity Index (EI) and Sensitivity Index (SI) for selected variables from Table 2

| | Model Output Response | Model Input Parameters | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SWP Table A Demand | Article 21 Demand | Banks Pumping Limit | Historical Land Use | Projected Land Use | Crop ET | Basin Efficiency | SWP Delivery-Carryover Curve | SWP San Luis Rule Curve | Shasta Inflow | Oroville Inflow | Folsom Inflow |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | SWP Total Delivery | | 0.01 (0.16) | | 0.09 (-0.13) | -0.05 (-0.03) | 0.00 (0.00)* | -0.15 (0.10) | -0.01 | 0.02 | 0.07 (0.05) | 0.18 (0.19) | 0.05 (0.14) |
| 2 | CVP total Delivery | -0.01 (-0.01) | 0.00 (0.00)* | -0.01 (-0.13) | 0.10 (-0.18) | 0.14 (0.11) | 0.16 (0.09) | | 0.00* | 0.00* | | 0.05 (0.07) | 0.03 (0.09) |
| 3 | SWP SOD Delivery | | 0.00 (-0.01) | | 0.12 (-0.13) | -0.09 (-0.04) | -0.21 (-0.08) | -0.17 (0.08) | -0.02 | 0.00* | 0.08 (0.04) | | 0.05 (0.12) |
| 4 | SWP NOD Delivery | -0.01 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.00 (0.00) | 0.17 (0.02) | 0.78 (0.08) | -0.17 (0.02) | 0.00 | 0.00* | 0.00 (0.00) | 0.01 (0.00) | 0.00 (0.00) |
| 5 | Article 21 Delivery | -2.62 (-0.12) | 0.15 (0.17) | | | -0.05 (0.00) | -0.03 (0.00)* | 0.30 (-0.01) | 0.08 | 0.46 | 0.34 (0.01) | -0.51 (-0.02) | 0.16 (0.02) |
| 6 | CVP SOD Delivery | -0.01 (-0.01) | 0.00 (0.00)* | -0.02 (-0.10) | 0.15 (-0.15) | -0.25 (-0.11) | -0.27 (-0.09) | -0.10 (0.04) | 0.00* | 0.00* | -0.38 (0.18) | 0.08 (0.06) | 0.04 (0.08) |
| 7 | CVP NOD Delivery | 0.00 (0.00) | 0.00 (0.00)* | 0.00 (-0.02) | 0.03 (-0.03) | | 0.46 (0.18) | | 0.00* | 0.00* | 0.10 (0.04) | 0.02 (0.01) | 0.01 (0.01) |
| 8 | Total Delta Outflow | | 0.00 (-0.16) | | | | | -0.07 (0.15) | 0.00 | 0.00 | | | |
| 9 | Banks Export | | 0.01 (0.16) | | 0.11 (-0.14) | -0.11 (-0.06) | -0.20 (-0.08) | -0.14 (0.08) | -0.01 | 0.02 | 0.10 (0.06) | 0.21 (0.18) | 0.05 (0.14) |
| 10 | Tracy Export | -0.01 (-0.01) | 0.00 (0.00)* | -0.02 (-0.10) | 0.16 (-0.15) | -0.25 (-0.10) | -0.28 (-0.09) | -0.10 (0.04) | 0.00* | 0.00* | -0.39 (0.18) | 0.09 (0.06) | 0.04 (0.08) |
| 11 | Banks SWP Export | | 0.01 (0.16) | | 0.11 (-0.13) | -0.10 (-0.05) | -0.20 (-0.08) | -0.14 (0.07) | -0.01 | 0.02 | 0.08 (0.05) | -0.22 (0.18) | -0.06 (0.14) |
| 12 | Banks CVP Export | -0.53 (-0.02) | 0.00 (0.00) | 0.79 (0.17) | 0.42 (-0.01) | -0.37 (-0.01) | -0.43 (0.00) | -0.31 (0.00) | 0.00 | 0.02 | 0.86 (0.01) | 0.04 (0.00) | 0.02 (0.00)* |

Note: (1) Values inside parentheses are SI and outside are EI. Values with asterisks indicate that EI and SI are not monotonic functions.
(2) Cell with an asterisk (*) indicates that the SI and EI of that output variable are non-monotonic functions of the corresponding input parameter. Please refer to the main report for details.

| | |
|---|---|
| Moderate Sensitivity | 0.1 <= \|SI\| <= 0.2 |
| Low Sensitivity | \|SI\| < 0.1 |





An examination of Row 3 of Table E-1 highlights the behavior of SWP Delta delivery with respect to changes in some of the key input parameters. It shows that the SWP Table A demand, the Banks pumping limit, and the Oroville inflow affect SWP Delta delivery the most. Folsom inflow and historical land use display moderate effects on the SWP Delta delivery. A positive SI of 0.52 for the SWP Table A demand indicates that the SWP Delta delivery will increase by an average of 0.52 taf if the SWP Table A demand increases by 1 taf; and a positive EI of 0.55 for the SWP Table A demand indicates that the SWP Delta delivery will increase by an average of 0.55 percent if the SWP Table A demand increases by one percent. Similarly, a positive SI of 0.20 for the Oroville inflow indicates that the SWP Delta delivery will increase by an average of 0.20 taf if the Oroville inflow increases by 1 taf; and a positive EI of 0.26 for the Oroville inflow indicates that the SWP Delta delivery will increase by an average of 0.26 percent if the Oroville inflow increases by one percent.

No SI values are computed for input parameters of the SWP Delivery-Carryover Curve and the SWP San Luis Rule-curve (see Columns 8 and 9) because the equivalent changes in the commensurate units of taf are difficult to define for these two parameters. A more detailed discussion of their impact on the SWP Delta delivery is presented in the Memorandum Report.

## Future Work

Further analysis of this sensitivity study will be done to develop more detailed findings regarding the impact of various parameters on SWP Delta deliveries.

This sensitivity study is mainly focused on Sacramento Valley hydrology, Sacramento-San Joaquin Delta water quality, and SWP operations. Additional sensitivity studies focused on San Joaquin Valley hydrology and CVP operations are planned for the near future by Reclamation.

Linear programming solution methodology used in the CalSim II model has the potential to produce an array of sensitivity analyses as a by-product of the linear programming analysis automatically. Discussion of these results will provide a degree of transparency to model users and an internal diagnostic tool that the current CalSim II does not provide. Studying these by-products of the linear programming solution procedure will be considered during the development of the next generation of the CalSim II model.

The CALFED report, A Strategic Review of CalSim-II and its Use for Water Planning, Management, and Operations in Central California (December 2003), recommends a model uncertainty analysis be conducted. An uncertainty analysis is not the same as a sensitivity analysis. It takes a set of randomly chosen input values (that can include parameter values), passes them through a model to obtain the probability distributions (or statistical measures of the probability distributions) of the resulting outputs, while a sensitivity analysis attempts to determine the relative change in model output values given modest changes in model input values. The uncertainty analysis would help users of the model understand better the risks of various decisions and the confidence they can have in various model predictions. DWR is currently working on a contract with University of California, Davis to develop a strategy for the evaluation of the major sources of uncertainty in CalSim II modeling studies, and to implement a recommended procedure for the quantification of uncertainties in a CalSim II study.

## Websites for the Memorandum Reports:

1. [DWR] California Department of Water Resources, Bay-Delta Office. 2003. CalSim II Simulation of Historical SWP/CVP Operations. Technical Memorandum Report. Availability: http://science.calwater.ca.gov/pdf/CalSim II Simulation.pdf
2. [DWR] California Department of Resources, Bay-Delta Office. 2005. CalSim II Model Sensitivity Analysis Study. Technical Memorandum Report. Availability: http://baydeltaoffice.water.ca.gov/

# Appendix F. Guidelines for Review of Proposed Permanent Transfers of SWP Annual Table A Amounts

This appendix contains a copy of the Notice to State Water Project Contractors Number 03-09 entitled "Guidelines for Review of Proposed Permanent Transfers of State Water Project Annual Table A Amounts".

These guidelines are being included per the Settlement Agreement, dated May 5, 2003, reached in the Planning and Conservation League et al. v. Department of Water Resources, 83 Cal. App. 4th 892 (2000).





STATE OF CALIFORNIA · RESOURCES AGENCY · DEPARTMENT OF WATER RESOURCES

## NOTICE TO

## STATE WATER PROJECT CONTRACTORS

NUMBER: 03-09 DATE: 7/3/03

SUBJECT: Guidelines for Review of Proposed Permanent Transfers of State Water Project Annual Table A Amounts

FROM: INTERIM DIRECTOR, DEPARTMENT OF WATER RESOURCES

The Department of Water Resources is issuing the following guidelines prepared in connection with the Settlement Agreement, dated May 5, 2003, reached in *Planning and Conservation League et al. v. Department of Water Resources, 83 Cal. App. 4th 892 (2000)*. These guidelines are effective upon the superior court's approval of the Settlement Agreement on May 20, 2003.

1. Purpose: The purpose of these guidelines is to describe the process for DWR's review of proposed permanent transfers of State Water Project Annual Table A Amounts and, by so doing, provide disclosure to SWP contractors and to the public of DWR's process and policy for approving permanent transfer of SWP Annual Table A Amounts. Such disclosure should assist contractors in developing their transfer proposals and obtaining DWR review expeditiously, and assist the public in participating in that review.

2. Coverage: These guidelines will apply to DWR's approval of proposed permanent transfers of water among existing SWP contractors and, if and when appropriate, to proposed permanent transfers of water from an existing SWP contractor to a new SWP contractor.

3. Interpretation: These guidelines are in furtherance of the State policy in favor of voluntary water transfers and shall be interpreted consistent with the law, including but not limited to Water Code Section 109, the Burns-Porter Act, the Central Valley Project Act, the California Environmental Quality Act, area of origin laws, the public trust doctrine, and with existing contracts and bond covenants. These guidelines are not intended to change or augment existing law.

4. Revisions: Revisions may be made to these guidelines as necessary to meet changed circumstances, changes in the law or long-term water supply contracts, or to address conditions unanticipated when the guidelines are adopted. Revisions shall be in accordance with the Settlement Agreement.

Notice to State Water Project Contractors
Page 2 JUL 3 2003

5. Distribution: The transfer guidelines shall be published by DWR in the next available edition of Bulletin 132, and also as part of the biennial disclosure of SWP reliability as described in the Settlement Agreement.

6. Contract Amendment: Permanent transfers of SWP water are accomplished by amendment of each participating contractor's long-term water supply contract. The amendment consists of amending the Table A upwards for a buying contractor and downwards for a selling contractor. The amendment shall be in conformity with all provisions of the long-term water supply contracts, applicable laws, and bond covenants. Other issues to be addressed in the contract amendment will be subject to negotiation among DWR and the two participating contractors. The negotiations will be conducted in public, pursuant to the Settlement Agreement and Notice to State Water Project Contractors Number 03-10.

7. Financial Issues: The purchasing contractor must demonstrate to DWR's satisfaction that it has the financial ability to assume payments associated with the transferred water. If the purchasing entity was not a SWP contractor as of 2001, special financial requirements pertain as described below, as well as additional qualifications.

8. Compliance with CEQA: Consistent with CEQA, the State's policy to preserve and enhance environmental quality will guide DWR's consideration of transfer proposals (Public Resources Code Section 21000). Identification of the appropriate lead agency will be based on CEQA, the CEQA Guidelines, and applicable case law, including *PCL v. DWR*. CEQA requires the lead agency at a minimum to address the feasible alternatives to the proposed transfer and its potentially significant environmental impacts (1) in the selling contractor's service area; (2) in the buying contractor's service area; (3) on SWP facilities and operations; and (4) on the Delta and areas of origin and other regions as appropriate. Impacts that may occur outside of the transferring SWP contractors' service areas and on fish and wildlife shall be included in the environmental analysis. DWR will not approve a transfer proposal until CEQA compliance is completed. The lead agency shall consult with responsible and trustee agencies and affected cities and counties and, when DWR is not the lead agency, shall provide an administrative draft of the draft EIR or Initial Study/Negative Declaration to DWR prior to the public review period. A descriptive narrative must accompany a checklist, if a checklist is used. The lead agency shall conduct a public hearing on the EIR during the public comment period and notify DWR's State Water Project Analysis Office of the time and place of such hearing in addition to other notice required by law.

9. Place of Use: The purchasing contractor must identify the place and purpose of use of the purchased water, including the reasonable and beneficial use of the water.





Notice to State Water Project Contractors
Page 3 JUL 3 2003

Typically, this information would be included in the environmental documentation. If a specific transfer proposal does not fit precisely into any of the alternatives listed below, DWR will use the principles described in these Guidelines to define the process to be followed. The information to be provided under this paragraph is in addition to the CEQA information described in Paragraph 8 of these guidelines.

a. If the place of use is within the contractor's service area, the contractor should disclose the purpose of the transferred water, such as whether the water is being acquired for a specific development project, to enhance overall water supply reliability in the contractor's service area, or some other purpose. If the transferred water is for a municipal purpose, the contractor should state whether the transfer is consistent with its own Urban Water Management Plan or that of its member unit(s) receiving the water.

b. If the place of use is outside the contractor's service area, but within the SWP authorized place of use, and service is to be provided by an existing SWP contractor, then, in addition to Paragraph 9(a) above, the contractor should provide DWR with copies of LAFCO approval and consent of the water agency with authority to serve that area, if any. In some instances, DWR's separate consent is required for annexations in addition to the approval for the transfer.

c. If the place of use is outside the SWP authorized place of use and service is to be provided by an existing SWP contractor, the contractor should provide information in Paragraph 9(a) and 9(b). Prior to approving the transfer, DWR will consider project delivery capability, demands for water supply from the SWP, and the impact, if any, of the proposed transfer on such demand. If DWR approves the transfer, DWR will petition State Water Resources Control Board for approval of expansion of authorized place of use. Water will not be delivered until the place of use has been approved by the SWRCB and will be delivered in compliance with any terms imposed by the SWRCB.

d. If the place of use is outside the SWP authorized place of use and service is not to be provided by an existing SWP contractor, DWR will consider the transfer proposal as a proposal to become a new SWP contractor. Prior to adding a new SWP contractor, DWR will consider project delivery capability, demands for water supply from the SWP, and the impact, if any, of the proposed transfer on such demand. DWR will consult with existing SWP contractors regarding their water supply needs and the proposed transfer. In addition to the information in Paragraph 9(a), 9(b), and 9(c), the new contractor should provide information similar to that provided by the original SWP contractors in the 1960's Bulletin 119 feasibility report addressing hydrology, demand for water supply, population growth, financial feasibility, etc.

State Water Project Contractors
JUL 3 2003
Page 4

DWR will evaluate these issues independently and ordinarily will act as lead agency for CEQA purposes. In addition, issues such as area of origin claims, priorities, environmental impacts and use of water will be addressed. The selling contractor may not be released from financial obligations. The contract will be subject to a CCP 860 validation action initiated by the new contractor. If DWR approves the transfer, DWR will petition the SWRCB for approval of expansion of authorized place of use. Water will not be delivered until the place of use has been approved by the SWRCB and will be delivered in compliance with any terms imposed by the SWRCB.

10. DWR Discretion: Consistent with the long-term water supply contract provisions, CEQA, and other provisions of law, DWR has discretion to approve or deny transfers. DWR's exercise of discretion will incorporate the following principles:

    a. As required by CEQA, DWR as an agency with statewide authority will implement feasible mitigation measures for any significant environmental impacts resulting from a transfer if such impacts and their mitigation are not addressed by other public agencies and are within DWR's jurisdiction.

    b. DWR will invoke "overriding considerations" in approving a transfer only as authorized by law, including but not limited to CEQA, and, to the extent applicable, the public trust doctrine and area of origin laws.

If you have any questions or need further information, please contact Dan Flory, Chief of DWR's State Water Project Analysis Office, at (916) 653-4313 or Nancy Quan of his staff at (916) 653-0190.



Appendix F. Guidelines for Review of Proposed Permanent Transfers of SWP Annual Table A Amounts

# Appendix G. Comment Letters on the Draft Report and the Department's Responses

Written comments from the public on the *Draft State Water Project Delivery Reliability Report* (November 2005) were accepted through December 2005. DWR reviewed the letters and made appropriate modifications to the report. These letters and the responses to them are contained in this appendix.

**Index**


Coachella Valley Water District ..... G-2
DWR response letter ..... G-4
Cuddy Valley Statistical Consulting ..... G-7
DWR response letter ..... G-12
Planning and Conservation League ..... G-15
DWR response letter ..... G-35
Arve R. Sjovold ..... G-55
DWR response letter ..... G-59
Robert C. Wilkinson ..... G-66
DWR response letter ..... G-69







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REDWINE AND SHERRILL, ATTORNEYS


December 29, 2005

File: 022.57
0644.103

Katherine Kelly, Chief
Bay-Delta Office
California Department of Water Resources
1416 9th Street, Room 215-37
Sacramento, CA 95814

Dear Ms. Kelly:

Subject: Draft 2005 State Water Project Delivery Reliability Report

On December 23, the Coachella Valley Water District (CVWD) e-mailed comments on the draft report, to Johnnie Young-Craig. This is a follow-up to that e-mail submittal. In response to the Department of Water Resources (DWR) Draft 2005 State Water Project Delivery Reliability Report, CVWD submits the following comments:

1. On page 18, the report states, "To simplify the use of this report, the calculation of demand or delivery in percent of maximum Table A is based on the maximum Delta Table A total of 4.133 maf for all five studies." CVWD believes that this approach may result in misleading conclusions if State Water Project (SWP) contractors simply rely on the percentages to estimate their supply reliability.

   Most SWP contractors (with the probable exception of Metropolitan) would be expected to request their full Table A amounts, regardless of the water year type. However, when some contractors request less than their full Table A amount, more water should be available for allocation to other contractors. The use of the maximum Table A amounts to compute the delivery percentages indicates a lower reliability for current (2005) demands than for future (2025) demands. This is demonstrated in Table 5-2, where Study 4 shows an average delivery of 68 percent of the maximum Table A, while Study 5 shows an average delivery of 77 percent. If the delivery percentages were expressed as a percent of the corresponding Table A demand, the results for the current demands would be higher. Study 4 would have an average delivery of 85.7 percent of Table A demand (281/3290 = 0.857) while Study 5 would have an average delivery of 77.3 percent of Table A demand (3178/4110 = 0.773). Similar calculations for maximum and minimum deliveries would also indicate the lower reliability of future SWP deliveries. For dry and wet years, it is recommended that percentages be based on the ratio of deliveries to demands for the corresponding years.

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Katherine Kelly
California Department of Water Resources 2 December 29, 2005

CVWD believes this computation would more accurately indicate the lower reliability of SWP deliveries in the future as demands increase. SWP contractors could then more directly apply the percentages to estimate their current and future Table A deliveries.

2. It is recommended that the probability charts shown on Figures 5-1 and 5-2 be revised such that the percentages are based either on the maximum demand requests, or the percentages be eliminated. While these figures correctly depict the deliveries in acre-feet, they seem to imply that the project is better able to meet demands in the future simply because demands are closer to the maximum Table A amounts.

3. In Chapter 6, examples are presented on the application of the reliability data. Information from Table 6-1 is used to estimate the potential supplies under average, single dry and multiple dry years. Due to the method whereby the percentages are computed, the average supply is shown to increase over the next twenty years. In reality, the average supply would be spread over a greater demand. Using the average values computed under Comment 1 above, the average annual values in the example would be 85,700 acre-feet in 2005, decreasing to 77,300 acre-feet in 2025. If a contractor were to request less than its full Table A amount in 2005, then the requested amount would be used instead of the Table A value.

4. It is recommended that DWR include, in an appendix, a table showing the annual demands used for each contractor under 2005 and 2025 conditions. This information could then be used to interpret the results of the studies for a particular contractor.

CVWD wishes to thank DWR for the opportunity to comment on this report and looks forward to receiving the final version.

If you have any questions, please call Zachary Ahinga, Resource Engineer, at (760) 398-2661, extension 2510.

Yours very truly,

Steve Robbins
General Manager – Chief Engineer

ZAcsa\engr\resource\05\dec\kelly-draft 2005 State Wtr Project

COACHELLA VALLEY WATER DISTRICT





STATE OF CALIFORNIA – THE RESOURCES AGENCY ARNOLD SCHWARZENEGGER, Governor

**DEPARTMENT OF WATER RESOURCES**
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

January 30, 2006

Mr. Steven B. Robbins
Coachella Valley Water District
Post Office Box 1058
Coachella, California 92236

Dear Mr. Robbins:

Thank you for your comments on the Draft State Water Project Delivery Reliability Report 2005 (Report 2005). Your comments have been thoroughly reviewed and the recommended changes considered for inclusion into the final report.

I appreciate your concern that, by simplifying the presentation of the information, the report may cause the State Water Project (SWP) contractors to come to an incorrect conclusion about the ability of SWP to meet their needs. You make the point that the ability of the SWP to meet demands will decrease as these demands increase. This is certainly correct. A plot of studies 4 and 5 (from the draft report) showing how well the SWP is estimated to meet demand is attached. It shows that the amount of years under which at least 90 percent of the assumed SWP demand can be met drops from 70 percent for 2005 demands to 50 percent for 2025 demands. The final Report 2005 has been modified to assure that readers will not come to an incorrect conclusion regarding the estimated ability of SWP to meet future demands.

The final report has not been modified, per your request, to present the results as a percentage of assumed demand. The results contained in Report 2005 are shown as percentages of the maximum Table A amount so the information can be easily interpreted by SWP contractors and incorporated into their analyses. Presenting the information as a percentage of the assumed demand would require additional calculations and, we believe, would increase the potential for calculation errors. For example, with the data presented as a percentage of the maximum Table A amount, a contractor may apply a percentage value to the specific maximum Table A amount for his or her district to determine how much water would be available to the district. Once this is done, the capability of the district to convey that amount could be analyzed and the amount of supply reduced accordingly. If the information were presented as a percent of the demand, the amount of water that it equates to must be determined by referencing the assumed demand for a specific year and then calculating the amount of water associated with it. This is particularly cumbersome when calculating average values for any given period.

Mr. Steven B. Robbins
January 30, 2006
Page 2

Finally, you recommend an appendix be included showing the annual demands assumed for each SWP contractor for the 2005 and the 2025 studies. The values for the total annual assumed Table A demand for studies 4 and 5 are listed in Tables B-6 and B-7. Tables containing a breakdown of these values for each contractor would be very long and provide a relatively small increase in the usefulness of the report. Individual contractors are encouraged to contact DWR staff at (916) 653-1099 to discuss the specific applicability to their district of the information in the report.

I appreciate your review of this document. The final report will be available soon and will include your letter and this response in an appendix. If you wish to discuss this report further, please contact me at (916) 653-1099 or kkelly@water.ca.gov. Francis Chung, Chief of the Modeling Support Branch of the Bay-Delta Office, should be contacted for technical questions on the CalSim II modeling studies. He can be reached at (916) 653-5924 or chung@water.ca.gov.

Sincerely,

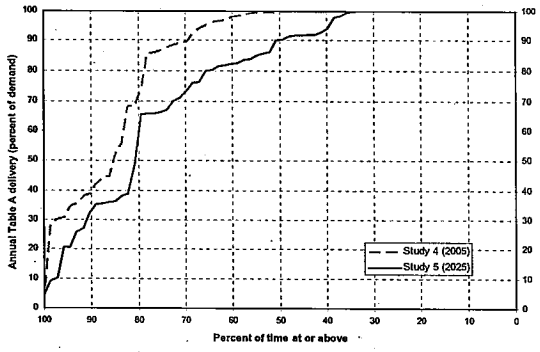
Katherine F. Kelly, Chief
Bay-Delta Office

Attachment





**SWP Delta Table A delivery probability for studies 4 and 5**



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California Department of Water Resources
SWP Delivery Reliability Report -- Attn: Johnnie Young-Craig
P.O. Box 942836
Sacramento, CA 94236-0001
Date 12/20/05

Dear Sir or Madam,

These are my comments on the 2005 Delivery Reliability Report. I have been studying the WRIMS/CALSIM methodology for some time, although this is made difficult by lack of documentation, non-availability of the WRIMS source code, use of proprietary libraries, and so on. Also, the CALSIM model is inherently very complicated, so it takes a long time to find out what the actual constraints and variables are. So my comments will necessary be of a general methodological character, without using any of the specifics of CALSIM. I think these general considerations are sufficient to argue that the delivery predictions made by CALSIM for the next 20 years cannot possibly be taken seriously. There may be a paucity of data, even in the past, but it simply will not do to compensate for this by making a multitude of seemingly unreasonable assumptions. It is obvious that modeling SWP/CVS is a gargantuan task, but the importance of Table A predictions for development in Southern and Central California is now so important that we really have to do better.

Let me explain what I understand WRIMS/CALSIM modeling to do. I may be wrong, because as I said good documentation is difficult to come by. The SWP/CVS system, or a subset of it, is modeled as the CALSIM network with hundreds of nodes and (valued) arcs. Flows through the system are modeled as arcs, and there are inflow, outflow, and through-flow nodes. There are many

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constraints on the flows, depending on capacity, environmental regulations, demands, and balance of inflows and outflows at through-flow nodes. Some outflows are deliveries, some inflows are runoff and rainfall. The objective function is a combination of delivery outflows. We choose flows in such a way that (a) they satisfy the constraints, and (b) over all possible flows satisfying the constraints they maximize the objective function. In actual WRESL modeling the objective function and the constraints are linear, which means that the optimization is actually a linear programming network optimization method. I don't discuss complications, such as using mixed integer programming and soft constraints, which generally make matters worse anyway.

To discuss the results of this process, and the way they are presented, define a function $F_N$ which gives as its value y the total delivery to the 29 SWP contractors and takes as input runoff and rainfall x. The structure of the CALSIM network, including all the constraints, is considered to be fixed. Thus $F_N$ transforms runoff and rainfall x uniquely to delivery y, for a given structure of CALSIM (and for a given objective function). In the delivery reliability studies DWR calculates $F_N$ (ca) for t=1,...,73 and for N a limited number of variations of the basic network. Here 73 is the number of years for which we have data, i.e. 1922 to 1994. One N is the network in 2005, another N the network in 2025. Those two networks are supposed to differ only in demand, not in the constraints defined by the infrastructure or regulations. Thus $F_N(x_t)$ is a time series of 73 different values, and as a next step DWR calculates for each number z the percentage of the 73 numbers $F_N(x_t)$ larger than or equal to z. Let's write this as $p_N(z)$. DWR calls $p_N(z)$ the probability that the delivery of network N will be at least z aft/year.

Now let us look at the assumptions inherent in this process. In the first place it assumes that $F_N$ represents the SWP/CVS system adequately. This means that if we assume that if N is the actually network at time t and $x_t$ is the actual rainfall at time t, then $y_t=F_N(x_t)$ should be at least close to the

observed deliveries at time t. This is basically all we want, but clearly a sufficient condition for this to be the case are that N represents the infrastructure and the constraints adequately and that the many people operating SWP/CVS act as if they are optimizing a particular linear function under the particular constraints used. Both these sufficient conditions are obviously false. It is known that the model does not adequately represent the environmental regulations, it is also know that the mix-and-match strategies used by suppliers to add ground water or banked water to the system are not adequately represented either. It is unknown how serious these violations are. From the system theoretic point of view it is not necessary to assume that the network is true and the operators are optimizers, the only thing we are interested in is if $y_t$ is sufficiently close to $F_N(x_t)$ (ands, eventually, if the predicted future observed $y_t$ will be close to the predicted $F_N(x_t)$.

Another assumption that seems inherent in the calculations is that $x_t$ is, in some sense, a random sample of size 73 of the possible values of rainfall/runoff in California, not just for now but also for the future. Now certainly there are large autocorrelations in the hydrologic time series $x_t$, so we certainly do not have independent observations. In fact, it is highly debatable if the notion of randomness applies here at all, and if we do not have a unique series of 73 observations for which there is no suitable framework of replication. Of course if randomness does not apply, then the notion of probability does not apply. But if randomness applies, then it should also be possible, and in fact highly desirable, to construct confidence regions for the $p_N(z)$ curves. Recently published time series also suggest that rainfall/runoff exhibit systematic trends, possibly related to climate change. So in particular extrapolating into the future may be risky.

For now, we will just insert some additional words of caution. A system that maximizes deliveries will obviously tend to overestimate deliveries. A system with hundreds and hundreds of variables can easily be manipulated to reproduce historic results, so future predictions are much more





important than close fit. Sensitivity analysis, i.e. changing the network from N to N', is definitely important but is a huge undertaking with a network as large as CALSIM. The assumption that the constraints (except for demand) and the structure of the network will remain basically the same until 2025 seem very arbitrary. The sensitivity study looks at some variation in the pumping done at Banks, but what we want to know, of course, is the actual level of pumping in future years. There is no way to tell what the environmental regulations in 2025 will be, because those depend on politics, climate change, and possible catastrophes.

DWR argues that the CALSIM projections are the best we have. This may be true, but it may be just a reflection of historical circumstances during development of the model. It certainly does not mean that it is the best we can do. DWR also argues, in many places, that past deliveries cannot be used to reliably predict future deliveries. This is dangerous nonsense. Of course they can. Even CALSIM uses them. It is true that the structure of the network and the constraints also play an important role, but ultimately all we have is a complicated way to relate the time series of runoff/ rainfall to the time series of deliveries to the SWP contractors. With the many threats to the Delta, which the possible impact of climate change, with the rapid population growth in Southern California, with the increasing demand of Northern California, with much less water from the Colorado River going to Southern California, we may have to face the fact that "best we have" is simply not good enough any more.

In summary, I do not think the DWR Delivery Reliability estimates are, themselves, very reliable. They are build on a host of unrealistic assumptions, that are "saved" by a model with the property that it always outputs a single number. And that single number is what the clients downstream are interested in. As far as I can see, a large fraction of that number is "model" or "virtual" water. It looks good on paper, but only water agency boards and modeling divisions can live on it.

Sincerely yours,

Jan de Leeuw

Director CVSC

Distinguished Professor and Chair, UCLA Department of Statistics





STATE OF CALIFORNIA -- THE RESOURCES AGENCY

ARNOLD SCHWARZENEGGER, Governor

**DEPARTMENT OF WATER RESOURCES**
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January 30, 2006

Dr. Jan de Leeuw
Cuddy Valley Statistical Consulting
11667 Steinhoff Road
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Dear Dr. de Leeuw:

This letter responds to your letter dated December 20, 2005 commenting on the Draft State Water Project Delivery Reliability Report (Report 2005). Most of your comments are regarding the suitability of the CalSim II computer simulation model for estimating the delivery reliability of the State Water Project (SWP).

You state that due to the lack of documentation for the CalSim model and its tremendous complexity, you may have a limited understanding of the model. Your general understanding of the model is correct with respect to its basic structure. It should be noted that CalSim II is not an optimization model but, rather, a system simulation model. The simulation is done on a monthly time step. It is not designed to maximize deliveries but to meet the assumed annual requested contractors' demands to the extent possible while meeting all physical, operational, and institutional constraints. The CalSim II modeled operation has been critically reviewed by both the SWP and the Central Valley Project operators and they are satisfied with the degree the model results mimic the actual real-world operations. The CalSim II model has been used extensively by State Water Contractors and SWP operation staff to help them develop annual water supply guidelines.

Over the past few years, there has been significant outreach to the interested public regarding CalSim II. Explaining what the model is and how it works is a big challenge given its complexity and the varying levels of understanding desired by interested parties. As you are aware, the CalSim II model has undergone a peer review (November 2003) which was open to the public and identified the strengths and weaknesses of the model. The peer reviewers produced a report of their findings (December 2003) to which the Department of Water Resources (DWR) responded (August 2004). This response includes a description of the goals for improving different aspects of CalSim and the plan for meeting them. Improving the credibility of the model with the interested public is a top priority in the plan. We will continue to strive to increase public understanding of the model.

Dr. Jan De Leeuw
January 30, 2006
Page 2

With respect to technical understanding of the model, documentation of the CalSim II Benchmark Studies (September 2002) and the associated assumptions is available on the Bay-Delta Office web site. This site also includes drafts of a CalSim Manual, Users Guide and WRSL Reference. In addition, an intense training session on CalSim was conducted in October 2003 for the interested public and was attended by 45 individuals. This training was designed to increase the technical understanding of the model, encourage informed discussion of the technical strengths and weaknesses of the model, and decrease the demand on DWR staff to conduct or assist with modeling studies by increasing the ability of other agencies and private consultants. This effort was very successful and DWR will conduct training sessions in the future as appropriate.

The CalSim II results in the Report 2005 are the best quantifications available of the delivery ability of the SWP but, as you point out, these estimates are limited because of the uncertainty of future conditions. DWR will continue to use the CalSim model as appropriate for analyses but other information is being developed that will help us analyze, understand, and prepare for our uncertain future. The potential impacts of climate change on the State's resources, including water supply, are being evaluated per the Governor's directive (Executive Order S-3-05). This effort includes broad brush estimates, using CalSim II, of the potential impact upon the SWP in 50 to 100 years if no additional conveyance facilities or upstream reservoirs are built. In addition, DWR is working on three projects that will improve our ability to make qualitative or quantitative statements about the reliability of conveyance across the Sacramento-San Joaquin Delta. These are: the Delta Risk Management Strategy, which will assess risks to the Delta from floods, seepage, subsidence, and earthquakes, evaluate the consequences of levee failure, and develop recommendations to manage the risk; implementation of AB 1200 (Laird, 2005) which calls for a similar evaluation of impacts on water supplies from catastrophic Delta failure; and a broader public process to develop a shared vision of a sustainable Delta that continues to support societal needs related to water supply, transportation, recreation, land use, energy, and environmental health. Although none of these efforts will be completed before release of the next Reliability Report, some preliminary results and conclusions may be done in time for inclusion. Subsequent Reliability Reports will fully incorporate this information.

In closing, the discussion of using past deliveries to predict future deliveries has been clarified in response to your comment. You comment that it is incorrect to state that past deliveries cannot be used reliably to predict future deliveries. We certainly believe, for the SWP, past deliveries cannot be reliably used to predict future deliveries because of the significant increase over time in the demand for SWP supplies.





Dr. Jan De Leeuw
January 30, 2006
Page 3

Thank you for your comments on the draft Report 2005. The final report will be available soon and will include your letter and this response in an appendix. If you wish to discuss the report further, please contact me at (916) 653-1099 or kkelly@water.ca.gov. Francis Chung, Chief of the Modeling Support Branch of the Bay-Delta Office, should be contacted for technical questions on the CalSim II modeling studies. He may be reached at (916) 653-5924 or chung@water.ca.gov.

Sincerely,

Katherine F. Kelly, Chief
Bay-Delta Office

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December 22, 2005

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*via facsimile to: (916) 653-6077*
*via email to:* Comments-on-2005DRR@water.ca.gov

Re: Comments on Public Review Draft of the State Water Project Delivery Reliability Report 2005

Ms. Kelly:

The Planning and Conservation League (PCL), a strong advocate for accurate and realistic water supply planning, submits the following comments on DWR's Public Review Draft of the State Water Project Delivery Reliability Report (Draft Reliability Report). As one of the signatories to the court-approved settlement agreement requiring DWR to prepare these biennial reliability reports, PCL seeks to ensure that the final report lives up to the rigorous reporting requirements specified in that agreement. Serious deficiencies are present in the Draft Report that, if left uncorrected, would dangerously overestimate DWR's future ability to deliver water and compound the risk that local planning decisions will be predicated on "paper" rather than deliverable water.

## The Reliability Report Should Accurately Disclose its Foundation in the Settlement Agreement and the State Water Project Contracts

The present Draft fails to inform local decision-makers and the public of the context and history behind DWR's reporting requirement. DWR's legal duty to prepare biennial reliability reports arises from the court-approved settlement agreement executed by PCL, DWR, state water contractors and other entities in the wake of the Third District Court of Appeal's ruling in the "Monterey Amendments" case, *Planning & Conservation League v. Department of Water Resources* (2000) 83 Cal. App. 4th 892.

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In *Planning & Conservation League*, the decision invalidating the Monterey Amendments EIR, the court bluntly addressed the "huge gap" between the 4.23 million acre-feet of SWP entitlements referenced in Table A of the SWP contracts and the half or less of that amount the state can reliably deliver. Recognizing the practical consequences of paper water for local development decisions, that court vindicated "the commonsense notion that land use decisions are predicated at some level on assumptions about available water supply. The Court also recognized that reliance on "paper water in local development decisions can produce excessive groundwater pumping and a host of other detrimental environmental consequences. " (83 Cal. App. 4th at p. 915.)

In the settlement decision following that ruling, DWR expressly agreed to add a rigorous new set of reporting requirements. In a new provision (Article 58) of the SWP contract, DWR committed to the following:

> 1.Commencing in 2003, and every two years thereafter, the Department Water of Resources (DWR) shall prepare and deliver to all State Water Project (SWP) contractors, all city and county planning departments, and all regional and metropolitan planning departments within the project service area a report which accurately sets forth, under a range of hydrologic conditions, the then existing overall delivery capability of the project facilities and the allocation of that capacity to each contractor. The range of hydrologic conditions shall include the historic extended dry cycle and long-term average. The biennial report shall also disclose, for each of the ten years immediately preceding the report, the total amount of project water delivered and the amount of project water delivered to each contractor. The information presented in each report shall be presented in a manner readily understandable by the public. (Settlement Agreement Attachment B)

The Settlement Agreement further states:

> 3. DWR shall provide assistance to enable all Municipal and Industrial Contractors to provide complete and accurate information to relevant land-use planning agencies to assure that local land-use decisions reflect accurate information on the availability of water from state, local, and other sources. (Settlement Agreement Attachment B)

The Draft Reliability Report does not fulfill these requirements. As detailed in the remaining sections of these comments, the Draft omits important information and misinterprets data, which would mislead both the public and local water agencies. Accordingly, it lacks the accuracy that the settlement agreement requires. In order to help DWR meet the commitments made under the settlement agreement, we submit the following comments for inclusion in the final 2005 Reliability Report.

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## Excerpts of the Reliability Report should not have been privately shared with the State Water Contractors, but denied to PCL and the public

We are aware that DWR provided an earlier draft chapter of the Draft Reliability Report to State Water Project contractors in May 2005 ("Excerpts from Working Draft 2005 SWP Delivery Reliability Report") and further recommended that local agencies incorporate information provided in that draft chapter in their Urban Water Management Plans (UWMPs). Castaic Lake Water Agency has acknowledged relying on that document in reviewing other projects, and other contractors may have done so as well. However, DWR did not provide that draft chapter to PCL or the public, even though PCL staff requested the opportunity to review the draft. After followup requests, we were informed that the draft chapter would be posted to a web page for contractor announcements. There was no public announcement informing interested parties of the availability of the draft chapter.

DWR's decision to circulate part of the report to the contractors, while denying that same document to PCL and members of the public, represents an unfortunate throwback to the defective process singled out for criticism in *Planning and Conservation League*, where the court took notice of the interested parties and members of the public who were "not invited to the table." (83 Cal. App. 4th at 905.)

## The draft and final Reliability Reports should be available to the public prior to deadlines for local agency Urban Water Management Plans

The most important purpose of the Reliability Report is to provide local water agencies and the public with accurate and realistic information on the reliability of SWP deliveries. Those local agencies should be able to use that information in planning documents and to inform land use decisions. Unfortunately, the timing of this report significantly compromises its utility. DWR did not release its draft to the public until just weeks prior to the state mandated deadline for local water agencies to complete and submit their 2005 Urban Water Management Plans.

DWR's decision to provide a single draft chapter prior to release of the full draft significantly compromises the information now included in many UWMPs. Without the complete report and the benefit of public review, decision-makers, planners and the public were denied the opportunity to evaluate and confirm the credibility of the information included in the draft chapter and now included in the UWMPs. Releasing the draft chapter and significantly delaying the release of this report is functionally equivalent to eliminating public oversight and transparency.

Water supply information from one chapter of a draft report also does not provide an adequate level of certainty or rigorous review required to determine the reliability of future water supplies for millions of Californians. To avoid damaging that review, water agencies and the public were supposed to have the complete final report, not just a preliminary part of it.

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DWR must ensure that in the future, the public will have ample opportunity to review and comment on Draft Reliability Reports, and that those public comments will be appropriately responded to and incorporated into vetted and substantiated final future reports well before Urban Water Management Plans are due to the State.

## The Reliability Report should include DWR's analysis of SWP reliability under anticipated effects of climate change.

The 2005 Draft Reliability Report recognizes that a primary factor in determining reliability of SWP supplies is the availability of water in source areas. Yet the Draft Report fails to discuss and incorporate known and recognized information regarding the substantial adverse impacts climate change will have upon California's water supply. This omission is particularly troubling because DWR previously committed to including such information.

In 2002 DWR's first Reliability Report recognized that climate change could significantly alter availability of water in source areas. The 2002 report stated that information on climate change impacts to California was being developed in the California Water Plan Update process, and that such information would be incorporated into the 2005 reliability report. The California Water Plan Update 2005 is now nearly complete, and it contains information on climate change. The April 7, 2005 draft of the Water Plan Update states:

> California's relies on snowpack as its largest means of annual water storage. Runoff from the Sierra Nevada mountains during April through July of each year averages 14 million acre-feet and comes primarily from snowmelt. Computer modeling of global climate change scenarios predict significant future reductions in the Sierra snowpack. A reduced snowpack will reduce the total water storage for the state. Figure 4-7 (Model simulation of potential changes in snowpack during the 21st Century) shows a 52 percent reduction in the annual April through July runoff for a 2.1 degree C (3.8 F) of warming, well within the 1.4 to 5.8 degree C (2.5–10.4 F) range predicted by global climate models for this century.
>
> Changes in the timing of snowfall and snowmelt, as a result of climate change, may make it more difficult to refill reservoir flood control space during late spring and early summer, potentially reducing the amount of surface water available during the dry season. Changes in reservoir levels also affect lake recreation, hydroelectric power production, and fish habitat by altering water temperatures and quality. Reductions in snowpack may require changes in the operation of California's water systems and infrastructure, and increase the value of additional flood control space in reservoirs.
> (Public Review Draft California Water Plan Update, April 7, 2005, Vol. 4, page 4-27)

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Despite the commitments made in the 2002 Reliability Report, this information is not included in the recent draft of the 2005 Delivery Reliability Report.

In addition, the Draft Reliability Report misleads readers by suggesting that information on climate change impacts in California is not available. Since the release of the Draft Reliability Report 2002, a large amount of analysis on potential climate change impacts on water management in California has been published. Yet, the Draft Report 2005 states:

> The studies do not incorporate any modifications to account for changes related to climate change or assess the risk of future seismic or flooding events significantly disrupting SWP deliveries. As tools are developed to address these risks and the resulting studies become available, the information will be incorporated into the assessment of SWP delivery reliability. The results of the CalSim-II studies conducted for this update to *The State Water Project Delivery Reliability Report 2002* (DWR 2003b) represent the best available assessment of the delivery capability of the SWP. (Draft Reliability Report page 17)

However, estimates of the deliveries from the SWP under climate change conditions have been modeled and analyzed. The California Energy Commission recently completed such an analysis in their report, "Predictions of Climate Change Impacts on California Water Resources Using CalSim-II: A Technical Note" (CEC report).

In contrast to the statement included in the Draft Reliability Report, the CEC report provides assessments of SWP delivery capability under several probable climate change scenarios. This work was prepared in response to Executive Order S-3-05 issued by Governor Schwarzenegger, which called for a report on the impacts to California of global warming, including impacts to water supply, public health, agriculture, the coastline, and forestry.

It includes analysis carried out using CalSim-II, some of it performed by DWR staff.
It is disappointing that it took the initiative of the Energy Commission to generate climate change scenarios that PCL has been requesting of DWR for over two years. Moreover, DWR cannot credibly represent that such studies are impossible even after they become publicly available. To claim otherwise would fatally compromise the commitment to accuracy that is the hallmark of DWR's reporting requirement.

The figures below from the CEC Report show that under climate change hydrologies, SWP deliveries at 75% reliability could be as much as 1.9 million acre feet less than the base condition.

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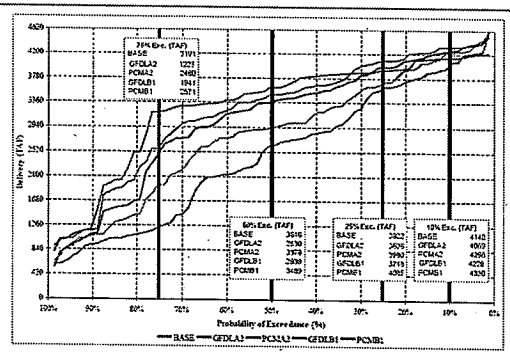


**Figure 7. Exceedance probability plot of SWP Annual Deliveries under climate change scenarios PCM B1-A2 and GFDL B1-A2 for 2070-2099**

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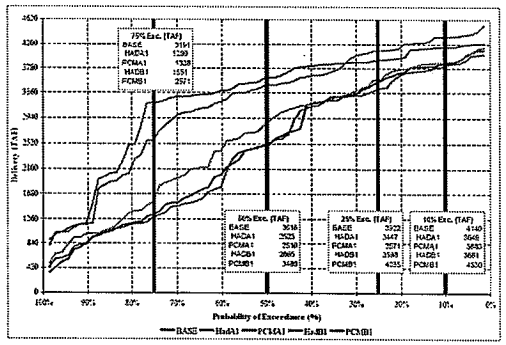


**Figure 8. Exceedance probability plot of SWP Annual Deliveries under climate change scenarios PCM B1-A1 and HadCM3 B1-A1 for 2070-2099**

(California Energy Commission, draft Predictions of Climate Change Impacts on California Water Resources Using CalSim-II: A Technical Note, December 2005 page 14 & 15 http://www.energy.ca.gov/2005publications/CEC-500-2005-200/CEC-500-2005-200-SD.PDF )

The CEC report concluded that modeling, "results show great negative impacts on California hydrology and water resources associated with most of climate change scenarios analyzed (only one scenario PCM run under B1 emission scenarios show just mild negative impacts)." (page 4)

This information demonstrates the range of outcomes that water managers must be prepared to address. This important assessment of the delivery capability of the SWP should be included in the Draft Reliability Report.

We also understand that DWR may have done its own analysis of the impacts of climate change on SWP deliveries. On the official State of California Climate Change Portal (http://www.climatechange.ca.gov/climate_action_team/reports/index.html) there is a reference to a study done by DWR. However unlike all of the other references, no results are included. The Reliability Report should include the results of DWR's own analysis.

Omission of this information prevents planners and decision makers from preparing for the inevitable implications for their water supplies. If the CEC already is predicting that water

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availability, and thus SWP deliveries, will be substantially reduced in the near future, water planners must adjust to that reality. DWR must address this problem, and will do California an enormous disservice if it continues to pretend that this problem does not exist.

Information in the Reliability Report will be used by local planners to make infrastructure investments and development decisions. The decisions made today about where to place infrastructure and where to approve development are long term commitments that will have impacts for hundreds of years into the future.

For instance, local decision-makers may chose not to place purple pipe in new development on the basis of assumed high level of delivery reliability from the SWP. Instead, decision-makers could choose to invest in new infrastructure to provide traditional supplies, including SWP supplies to new development. Once development is approved, the local area has foregone the opportunity to increase water supply reliability through use of recycled water. Should SWP supplies become significantly lower than predicted in the Reliability Report due to foreseeable impacts of climate change, significant local and statewide investments in infrastructure and housing would be stranded.

If local decisions are predicated on information from DWR that does not fully acknowledge potential constraints on DWR deliveries, they run the risk of producing excessive groundwater pumping and a host of other detrimental environmental consequences " (See *Planning and Conservation League*, 83 Cal. App. 4th at p. 915.)]

The long term nature and the resulting implications for the future of local areas as well as California as a whole, demand that the Reliability Report provide accurate, realistic information that fully discloses foreseeable uncertainty and risks.

The Report's unreliability also creates financial risks for the state. In many cases bonds will be committed to infrastructure built on expectations generated or encouraged by the Reliability Report. As with any financial investment, the risks associated with these investments must be fully disclosed to those who buy the bonds, those who approved the bonds, and those who invest in that infrastructure or in the developments supported by that infrastructure. As the state has learned in the past with levee liability, there is a potential risk that the State may be held accountable for decisions and investments made by others on the basis of false interpretation of the State's ability to protect and guarantee those investments.

### The Reliability Report should include risk analysis and impacts from catastrophic failure in the Bay Delta Estuary from earthquake or flood

The Draft Reliability Report correctly identifies the availability and means of conveyance as a primary factor in determining reliability of SWP supplies. However, like climate change impacts, the Draft Report fails to include analysis or discussion of serious and eminent risks to the Bay Delta

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Estuary, an essential component of the SWP conveyance system. Significant risks to the ability of the SWP to export water from the Bay Delta Estuary are posed by the vulnerability of levees to flood, sea level rise and earthquake, as well as environmental degradation and continued declines of important fish species.

Dr. Jeffery Mount from the University of California, Davis, recently completed a risk analysis estimating that there is a 64 percent probability that the Bay Delta Estuary will experience abrupt changes resulting from flooding or seismic activity within the next fifty years. These changes would permanently alter the hydrology, water quality and ecosystem of the Estuary. Furthermore, Dr. Mount found that there is no institutional capacity to address these permanent changes. (Subsidence, Seismicity and Sea Level Rise: Hell AND High Water in the Delta; presented by Dr. Jeffery Mount to the California Bay-Delta Authority October 14, 2004. http://calwater.ca.gov/CBDA/AgendaItems_10-13-14-04/Presentation/Item_13_6_Subsidence_Seismicity_Sea_Level_Rise.pdf)

In recent testimony to a joint committee of the California Legislature, Lester Snow, Director of DWR, outlined the serious risks to SWP water supply availability associated with Bay Delta levee failure. In his presentation, "How a Delta Earthquake Could Devastate California's Economy," Director Snow stated that extended impacts to water availability would include:

- Using most optimistic projection, levee repairs will require at least 15 months. More realistically, the repairs will take much longer.
- Southern California water agencies are drawing from reserves. Some will last up to 36 months; others will go dry sooner.
- Extreme water conservation measures enacted
- Ground water basins drawn dangerously down – may lead to contamination
- Water conservation and transfer programs enacted

(Slide 16 of Lester Snow's presentation to the joint legislative committee, November 1, 2005 http://www.publicaffairs.water.ca.gov/newsreleases/2005/11-01-05DeltaEarthquake.pdf )

Director Snow further indicated that recovery of the conveyance through the Delta could be abandoned. (Slide 19 of Lester Snow's presentation). Director Snow told the Legislature that "... we also need to recognize the Statewide impacts ...if Delta water supplies are reduced or eliminated as a result of a catastrophic failure of our levee system." (Quote taken from DWR Press Release, November 1, 2005, http://www.publicaffairs.water.ca.gov/newsreleases/2005/11-01-05flood.cfm)

Accordingly, the Reliability Report should incorporate Director Snow's recommendation to recognize the risk to SWP reliability from flood, sea level rise and earthquake.

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In addition to vulnerable levees, ecosystem degradation poses a significant risk to the ability to convey SWP water reliably through the Bay Delta Estuary. Recently, data from the Department of Fish & Game's Fall Mid Water Trawl signaled that there is a serious ecosystem collapse in the Estuary, with four important pelagic fish populations at historic lows, including the California and Federally Endangered Species Act listed Delta Smelt.

In response, many agencies, including DWR are participating in an emergency science review called the 'Pelagic Organism Decline' (POD) investigation. The most recent report from the POD investigations indicates that increased exports, which increase fish entrainment and decrease available habitat, may be a primary contributor to the fisheries declines ("Interagency Ecological Program Synthesis of 2005 Work to Evaluate the Pelagic Organism Decline (POD) in the Upper San Francisco Estuary," November 2005 http://science.calwater.ca.gov/pdf/workshops/IEP_POD_2005WorkSynthesis-draft_111405.pdf).

The final Reliability Report should acknowledge the current pelagic organism decline and disclose the possibility that decreases in exports may be necessary in order to reverse those declines. Lastly, while the pelagic species decline currently is the most salient of the Bay-Delta Estuary's environmental problems, it is not the only problem that might compel delivery reductions. Bay-Delta water currently does not meet federal or state water quality standards, and many other species are listed as threatened or endangered. The final Reliability Report should acknowledge that fixing these other environmental problems also may require export reductions.

**The Reliability Report should evaluate variable levels of demand, utilizing demand modeled in the Draft California Water Plan Update 2005**

The Draft Reliability Report identifies the level and pattern of water demand in the delivery service area as the third primary component in determining SWP reliability. However, the Draft Reliability Report does not examine a significantly varied range of possible demand scenarios for the future. That omission is important, for such analysis would likely show that reliability is inversely proportional to California's overall level of demand.

Recent work completed by DWR for the California Water Plan provides a range of demand scenarios that should be included in the Reliability Report. The California Water Plan Update 2005 identifies three plausible demand scenarios: current trends continued; less resource intensive; and more resource intensive. Two of these three scenarios demonstrate that it is plausible that in 2030 California water demands will *decrease*, even with an expected 12 million more residents. The greatest decreases in water demands in every scenario occur in the SWP service area of Tulare Lake.

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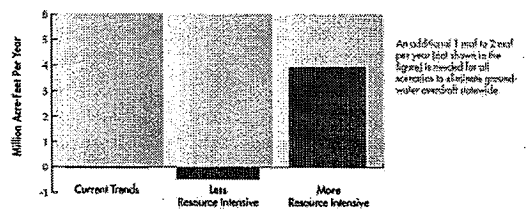
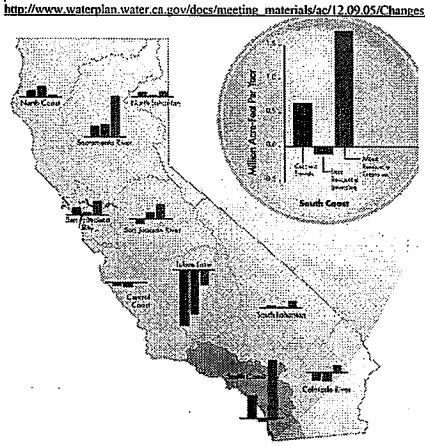
Figure 4-2 Net changes statewide in average year water demand for baseline scenarios, 2000-2030




Water demands may change between 2000 and 2030 for average water conditions. Statewide water demand changes are shown for three baseline scenarios.

http://www.waterplan.water.ca.gov/docs/meeting_materials/ac/12.09.05/Changes_to_PRD_Slides_(12-08-2005).pdf

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http://www.waterplan.water.ca.gov/docs/meeting_materials/ac/12.09.05/Changes_to_PRD_Slides_(12-08-2005).pdf

Recently, the California Court of Appeals determined that state and Federal water agencies erred when they failed to adequately assess a range of reasonable scenarios in the CALFED ROD EIR in part because the environmental document did not include an analysis of reduced pumping from the Bay Delta Estuary (*In Re Bay Delta Programmatic Environmental Impact Report Coordinated Cases* (2005) 133 Cal.App.4th 154). Consistent with this finding, and DWR's recent good work on the State Water Plan Update, the Reliability Report should evaluate reliability under the three demand scenarios presented in the California Water Plan Update.

**The Reliability Report should be consistent with operations described in environmental reviews**

The Draft Reliability Report assumes that SWP deliveries into the future will be much higher than historic averages. In the past, SWP deliveries have averaged about 2 maf per year, while the Draft Reliability Report proposes that future deliveries will average from 2.8 to 3.1 maf annually. The Draft Reliability Report also assumes that an additional maximum of 1.11 maf of water could be delivered under Article 21.

Because CalSim-II is an optimization model that does not necessarily reflect options available to water operators, it may predict these levels of exports. However, federal and state water quality and endangered species laws and regulations probably would prohibit such high export levels for water quality problems and if species impacts were chronic even at historic levels. In light of the recent pelagic organism declines in the Bay Delta Estuary, it is prudent to ensure the Draft Reliability delivery predictions would not violate conditions of the Federal Clean Water Act, the Federal or California Endangered Species Acts, or any other environmental permit condition, regulation, standard, or law.

In order to ensure that stated water deliveries would be legally feasible, the Reliability Report must explicitly state whether listed export levels are consistent with those modeled in environmental reviews, including the recently issued biological opinions. For instance, the Reliability Report should state whether the Biological Opinions for OCAP in 2004 accounted for impacts to listed species under a modeling scenario that contemplated deliveries of 1.11 million acre feet of Article 21 water.

**The Reliability Report should not recommend that water agencies integrate Article 21 as firm annual supplies in planning documents**

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Article 21 water is by definition interruptible water; indeed, the word "interruptible" replaces the formerly used "surplus" in the Monterey Amendments. It should not be used as the basis for uninterruptible demands. Yet in chapter 6 of the Draft Reliability Report, local agencies are encouraged to include Article 21 water in a table of average annual values.

As DWR is aware, water supplies accounted for in the Urban Water Management Plans become the basis for approval of water supply assessments for new development in California. It is not only imprudent, but would provide institutional cover for unreliable planning, to recommend that local decision-makers approve housing that will be dependent on water that is 'interruptible.'

Article 21 water should be removed from the recommended table of average annual deliveries.

**Use of CalSim-II as the sole tool to determine reliability is inappropriate given the following significant and yet to be resolved deficiencies**

The lack of calibration and other deficiencies of CalSim-II have been made known the DWR in formal comments on the 2002 Draft by several parties, specifically Arve Sjovold and Dennis O'Conner. In addition, a 2003 expert peer review report documented numerous problems in CalSim II, and concluded that its predictions should be treated as "hypotheses." A. Close et al., A Strategic Review of CalSim II and its User for Water Planning, Management and Operations in California 13 (2003). This Draft has not adequately addressed those deficiencies. Some of these previously-highlighted deficiencies are listed below.

- CalSim-II has not been calibrated or validated
- It is unclear whether CalSim-II incorporates limitations to groundwater use in the Sacramento Valley
- The CalSim-II model should not be used to make absolute predictions, such as those incorporated into the Reliability Report
- CalSim-II does not recognize or report uncertainty

Additionally, CalSim-II may produce results not consistent with reality, replacing the problem of paper water with an even greater problem of 'cyber water.' For example, in 2001, California experienced water supply associated with approximately the 75% exceedence level, and the State Water Project was able to deliver 1,607,570 ac-ft. However, the CalSim-II simulations predicted a 75% exceedence level of supply of roughly 2,500,000 ac-ft (as read from Figure 5.1). In other words, CalSim-II overpredicted deliveries by more than 50%. These discrepancies demonstrate the need to use multiple tools to determine reliability, as well as the need to articulate limitations of this particular model. Similarly, they demonstrate that local agencies will take enormous risks if they approve projects in reliance on CalSim II's predictions that future deliveries will be substantially higher than historic deliveries.

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The Draft Reliability Report attempts to respond to the recent to the recommendations and conclusions from the recent CBDA Peer Review, *A Strategic Review of CalSim II and its Uses for Water Planning, Management, and Operations in Central California* (Close and others 2003).

The Draft Reliability Report states:

> In *Peer Review Response,* DWR and USBR (2004) conclude the concern about overestimations of south-of-Delta deliveries is unwarranted because the 73-year study referenced by the panel is not designed to mimic historical conditions; rather it is intended to determine the reliability of the SWP when the demand equals the maximum Delta Table A amount (4.133 MAF) every year. The results of the referenced study are documented in *The SWP Delivery Reliability Report 2002*
> (DWR 2003b) as study 3 (2021B).
>
> A more appropriate method for assessing the ability of CalSim II to accurately model SWP operations is to compare the historical SWP deliveries with the simulated deliveries of the Historical Operations Study. DWR committed to conducting this study in *The SWP Delivery Reliability Report 2002* (DWR 2003b). The study is documented in the November 2003 Technical Memorandum Report *CalSim-II Simulation of Historical SWP/CVP Operations* (DWR 2003a). The Historical Operations Study is designed to assess CalSim II's ability to mimic historical operations of the SWP. In this study, historical input is used where reliable data are available. In situations where reliable historical record is not readily available, reasonable assumptions and estimates are made. (pages 10 & 11)

Before stating that this approach is the most appropriate response to the Peer Review concerns, DWR should reconvene the panel in order to review whether DWR's response satisfies the concerns raised in the original peer review. To verify that this response appropriately satisfies the concerns raised by that panel.

Additional specific comments on uses of CalSim-II in the Draft Reliability Report 2005 are attached in Appendix A.

**Conclusion**

**PCL hopes that these comments assist DWR in arriving at a final version of the Reliability Report that corrects the serious deficiencies identified in the draft, and provides the**

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**additional analysis recommended here. Without these additional efforts, the report would not fulfill DWR's responsibilities under the settlement agreement and the Article 58 of the SWP contracts, and would fail to provide local decision-makers with a credible basis to ensure that development decisions are grounded in an accurate assessment of deliverable SWP supply.**

Sincerely,

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Water Program Manager
Planning and Conservation League

Cc:
Lester Snow, Director , Department of Water Resources
Antonio Rossmann, Rossmann & Moore, LLP
Roger Moore, Rossmann & Moore, LLP
Dave Owen, Rossmann & Moore, LLP
Senator Kuehl,
Senator Machado
Senator Kehoe
Senator Ducheny
Senator Perata
Assemblywoman Wolk
Kip Lipper, Senator Perata's office
Carol Baker, Speaker, Assemblyman Nunez's office
Susan Kennedy, Chief of Staff
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**APPENDIX A: Specific comments on uses of CalSim-II in this Draft Reliability Report are highlighted below.**

**Page 7: "Whatever assumptions are made, every responsible water delivery reliability analysis should expressly state the assumptions, methods and data used to produce its results. It should also be understood that those numbers depend on, and are no better then, the assumptions upon which they must necessarily rest."**

This statement is entirely true. Yet this particular "water delivery reliability analysis" does not measure up to its own standard, because it does not adequately disclose the weaknesses of the key assumptions it makes and the key model upon which it relies. The reliability report should acknowledge that the simulated levels of SWP deliveries reported on the Draft Reliability Report are defined entirely by the explicit and implicit assumptions used in CalSim-II—they are CalSim-II's reliability results and not the results for the physical system itself—and should address the potential weaknesses in the "assumptions, methods and data" used to make those predictions.

Additionally, a statement such as this is so important that it should be made prominently, perhaps in a highlighted text box, rather than at the end of a paragraph in the body of the report.

**Page 7: "For example, the demand 30 years ago for the SWP was not as high as it is currently or expected to be in the future. Because the need for SWP water then was relatively low, less water was exported through the SWP during normal and wet times then could have been if the demand had been higher. Simply put, less water was delivered because less water was needed."**

The implicit assumption in this statement that there was no logic for contractors to take the water they were entitled to under Table A because 1) they had no need for it at that time, and 2) they had no place to store it for later use. If the assumption is that now and into the future the contractors will want to take delivery of their full Table A amounts—in other words, that circumstances have changed—then one or both of two conditions must be true 1) they need it and/or 2) they can store it. The reliability report should substantiate its reasons for assuming such a change in conditions.

On page 15, the Draft Reliability Report states that studies 4 and 5 were developed in discussions with SWP contractors and stakeholders involved with the development of the analysis associated with the environmental documentation for the Monterey Agreement. What analysis of current or future demand patterns and our available storage capacities is used to justify the assumption of a demand for the full Table A allotments? What are the assumptions about population growth, water use rates, availability of non-SWP supplies and available local storage capacity that lead to the conclusion that contractors will consistently ask for full Table A allotments?

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**Page 7: "Conversely, the current or projected delivery capability of the a water project would be less if (1) demand for water from a water project was at its maximum level for many years, (2) no new facilities were built, and (3) the supply of the main sources of water was recently reduced because another entity with a prior water right increased its use of that source."**

This statement is unclear and counterintuitive. The Draft Reliability Report often argues that higher levels of demand will increase the delivery capability not decrease it. DWR should clarify the point it is trying to make here or eliminate this statement altogether.

**Page 8: "In the 2002 Reliability Report, the Department committed to conducting a comprehensive sensitivity analysis for assumptions contained in the CalSim-II model studies. This analysis is complete."**

While this analysis is reported on in the Draft Reliability Report, DWR has made no attempt to use the results of that analysis to comment on the results of the CalSim-II modeling conducted for the reliability investigation. This seems to defeat the purpose of conducting and reporting on the sensitivity analysis. An attempt to consider the implications of the sensitivity analysis is included later in these comments.

**Page 11: "The simulated deliveries in Figure 3-1 were adjusted for any differences between the historical and simulated carry-over storage in the SWP system reservoirs, Lake Oroville and SWP's portion of San Luis Reservoir."**
**Page 74 "(in Appendix E dealing with the Historical SWP/CVP Operations Simulation Technical Memorandum: Simulations of historically wet years, when the system was not supply constrained, may therefore be a poor indicator of the model's ability to accurately simulate future levels of development. Particular interest is therefore place on model results during the six-year drought of 1987-1992."**

The Draft Reliability Report appears to offers up the Technical Memorandum Report entitled *CalSim-II Simulation of Historical SWP/CVP Operations* in order to support the legitimacy of the using CalSim-II to conduct the reliability analysis. If this is the goal then these two statements are problematic.

While the Draft Reliability Report gives no clear indication about what the adjustments referred to on page 11 entail, the fact that adjustments had to be made to generate the claimed correspondence shown in Figure 3-1 cannot stand without further explanation. The goal of the *CalSim-II Simulation of Historical SWP/CVP Operations* Technical Memorandum should have been to see if CalSim-II could be used to faithfully reproduce all aspects of system operations, not simply the SWP exports during the 1987-1992 drought. If the storage levels in SWP reservoirs were not faithfully reproduced and had to be adjusted in some unexplained way to generate the results in Figure 3-1, then the Technical Memorandum should not be used to build the creditability of the CalSim-II.

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In the same way, the comment in Appendix E that only the results for drought periods are critical for reliability analysis is not valid. The Technical Memorandum is being offered as support for the use of CalSim-II, not as a part of the reliability analysis itself. The claim that is being made is that the model faithfully replicated history and therefore has creditability in terms of simulating future conditions. The apparent recognition that the model did not do particularly well in normal and wet periods calls into question the validity of this claim.

In addition, even if CalSim II did accurately simulate deliveries in one past drought, that does not mean it can accurately simulate deliveries in a future drought, for constraints on the system are likely to be different. Water quality standards and endangered species protections have changed substantially since the 1987-02 drought, largely because the standards in place during that drought proved insufficiently protective. If the same drought conditions were to recur in the future, those heightened protections would likely prevent the SWP from exercising the same delivery capacity. CalSim II's predictions that those past diversions would be repeated therefore may prove the model's inadequacy rather than its credibility.

In keeping with the first comment, the inconclusive and somewhat opaque presentation of the *CalSim-II Simulation of Historical SWP/CVP Operations* Technical Memorandum results suggest that this report is about the reliability of SWP deliveries in the CalSim-II model and that the CalSim-II model is not a fully faithful representation of the how the system has been or presumably will be operated. Once again, it is fair to point out that if one wants to imagine future conditions then one must use some sort of model but the reader should not be left with the assumption that CalSim-II is a fully faithful representation of the system.

As an aside, Table 4 of the *CalSim-II Simulation of Historical SWP/CVP Operations* Technical Memorandum offers the most real, albeit limited, assessment of the reliability of the actual system if one is to assume that at some point in the future SWP contractors will consistently request their full Table A allotments. In 2001, contractors requested 4,124,126 ac-ft of SWP water and were allotted 1,607,570 ac-ft of supply. In 2003, contractors requested 4,126,929 ac-ft of SWP water and were allotted 3,714,233 ac-ft supply. These are two points on the exceedence curve of the real system reliability, certainly not enough to develop a robust reliability assessment. It is interesting to point out, however, that these delivery levels fall at roughly the 85% and 8% exceedence levels on the results for Study 4 that are meant to approximate current levels of development and demand (Figure 5.1). In terms of the hydrologic conditions 2001 and 2003 fall at approximately the 77% and 42% exceedence levels in terms of the Sacramento Valley water year index values for the period from 1922 to 1994 period simulated in CalSim-II. While far from a perfect metric for evaluating the performance of CalSim-II, this points out how the operations of the real system under roughly current conditions when nearly the full Table A amount was requested by the contractors compare with the simulated results.

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In terms of system reliability during dry periods, the most interesting conclusion to draw from this comparison is that actual operations in 2001, which benefited from a water supply associated with approximately the 75% exceedence level, provided a level of service of only 1,607,570 ac-ft while the CalSim-II simulations yielded a 75% exceedence level of supply of roughly 2,500,000 ac-ft (as read from Figure 5.1).

**Page 16: "The Article 21 demand in the updated studies (4 and 5) is higher than the earlier studies for the December through March period."**

It does not appear that DWR makes any attempt to explain why these higher levels were assumed. They are used in CalSim-II to prompt an export of water to SWP contractors when conditions warrant. While the Draft Reliability Report fairly comments on page 17 that "Incorporating supplies received under Article 21 into the assessment of water supply reliability is a local decision based on specific local circumstances, facts and level of water supply reliability required", including these numbers that are driven by a somewhat unjustified level of assumed Article 21 demand is not the clearest manner in which to present reliability analysis.

**Page 25: "By referencing the curve for Study 5 in Figure 5-2, the following can be deduced":**

- *In 75 percent of the years, the annuall delivery of the SWP is estimated to be at of above 2.7 maf per year (65 % of 4.13 maf).*

There is nothing special about the 75, 50 and 25% thresholds used in providing a narrative description of Figure 5.2 In fact it is equally valid to open and close the list of bullets with statements like:

- The maximum amount of water that can be delivered in response to full Table A demands with 100 percent reliability, in the CalSim-II model, is 187,000 ac-ft.
- Under the least supply constricted conditions the SWP will be able to deliver, in the CalSim-II model, the full Table A allotments.

Without even worrying about whether or not the assumptions used in the CalSim-II model are valid or not, these two statements are as valid as the three offered by DWR and they create a much different impression of SWP reliability.

Even if 100% reliability is not a valid standard, water utility plans for a system that will fail 25% of the time, as is the corollary of the 75% exceedence, are no more valid. Municipal utilities are often looking for, 90-95% reliability. According to these standards, Figure 5-2 suggests that the reliability of the system is between 1.4 maf and 0.8 maf. These numbers, which are no more or less valid than those reported by DWR, are perhaps more useful for water managers in assessing the reliability of a water supply.

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**Page 26: "In the case of 1977, it is reasonable to assume that up to 500 taf of 1976 allocated Table A water could be carried over to 1977."**

This sort of conditional post-processing of model output, which could have ripple effect across the rest of the simulation with potential changes in model results, is not valid and this whole section should be removed. To its credit DWR does not try and use any of this after the fact hand waving in the Table and Figures published in the Draft Reliability Report. Nonetheless, by including this narrative DWR is attempting to argue both that the model can be trusted and that the model cannot be trusted. This is not legitimate model interpretation.

**Page 49: "The estimate could be viewed as too low because the Department of Water Resources (DWR) is planning to have facilities in place by 2025 that will increase the reliability of the SWP. The estimate could be viewed as too high because there is the potential for exports to be required to be reduced to protect endangered fish species."**

It is inappropriate to speculate on what deliveries could be with new facilities when the information is to be used under the provisions of Senate Bill 221 to verify that water supplies are available for new developments.

**Page 78: "Table E-1 Summary of the Expected Elasticity Index (EI) and Sensitivity Index (SI) for Selected Variables."**

These very interesting results are included in the Draft Reliability Report and are then ignored completely interpreting the results of the reliability analysis. Let us for example attempt to recast the statement offered above:

- The maximum amount of water that can be delivered in response to full Table A demands with 100 percent reliability, according to the CalSim-II model, is 187,000 ac-ft.

If the sensitivity analysis is valid, it is legitimate to make the following statements.

- If the assumed levels of Banks Pumping vary by ±10% relative to the base level assumed in the CalSim-II simulation, then the maximum amount of water that be delivered in response to full Table A demands with 100 percent reliability, in the CalSim-II model, will very between 184,195 and 189,805 ac-ft.
- If the assumed levels of Oroville inflows vary by ±10% relative to the base level assumed in the CalSim-II simulation, then the maximum amount of water that can be delivered in response to full Table A demands with 100 percent reliability, according to the CalSim-II model, will very between 182,138 and 191,862 ac-ft.

DWR should either make these sorts of statements or they should not attempt to use the results of the sensitivity analysis to assert the legitimacy of the use of CalSim-II for SWP reliability analysis.

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California Affiliate
NATIONAL WILDLIFE FEDERATION

STATE OF CALIFORNIA -- THE RESOURCES AGENCY

ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

April 20, 2006

Ms. Mindy McIntyre
Water Program Manager
Planning and Conservation League
921 11th Street, Suite 300
Sacramento, California 95814

Dear Ms. McIntyre:

This letter responds to your letter dated December 22, 2005 providing comments of the Planning and Conservation League on the draft of the State Water Project Delivery Reliability Report–2005 (DRR (2005)). Your letter expresses concern regarding the adequacy of the analysis, criticizes the timing of the release of the report, makes several recommendations for improvement, and includes an attachment with comments regarding specific statements in the draft report. The following addresses the body of your letter. Responses to the detailed comments in the attachment of your letter are included as an attachment to this letter.

Your letter states that the draft DRR (2005) should mention that it is required per the settlement agreement to the case *Planning and Conservation League v. Department of Water Resources* (2000) 83 Cal. App. 4th 892. The final report includes such a statement. Your comment also says the draft DRR (2005) does not satisfy the requirements of the settlement agreement. This report is the first one issued since the settlement agreement became effective in May, 2003 and updates an earlier report (The State Water Project Delivery Reliability Report–2002). The 2002 report was designed to meet the requirements of the attachment to the settlement agreement, which was very near final at that time. Both reports include useful information for State Water Project (SWP) contractors, planners and interested parties on the delivery capability of the SWP. The Department of Water Resources (Department) believes these reports fulfill the requirements of Principle 1 in Attachment B of the settlement agreement. It should be noted that, although not a requirement of the settlement agreement, drafts of each report underwent public review. We believe this process improves the final report. The final of the first report was revised in response to public comments and the comment letters and their responses were included as an appendix. The final DRR (2005) has been modified in a similar way.





Ms. Mindy McIntyre
April 20, 2006
Page 2

You comment that the use of CalSim-II as the sole tool for determining reliability is inappropriate due to the lack of calibration and other deficiencies as identified in comments on the draft 2002 report and due to inadequacies mentioned in the peer-review report, *A Strategic Review of CalSim-II and its Use for Water Planning, Management, and Operations in Central California* (Close and others 2003). The final 2002 report includes thorough responses to the comments received on the draft 2002 report. Updated responses to the issues regarding CalSim-II mentioned in your letter are included in Attachment 2 to this letter. As mentioned in the draft DRR (2005), several studies have been conducted analyzing the ability of CalSim-II to simulate water project operations. The results support the conclusion that CalSim-II is a useful and appropriate tool for assessing the delivery capability of the SWP. You also comment that the peer reviewers should be reconvened to review the Department's written response to their review. The peer review of CalSim-II was an intensive and expensive effort involving many staff hours to develop the background information for the reviewers and handle the administrative details for the participation of the panel members and the two-day public meeting of the review itself. Some of the panel members, as well as other experts who were not on the panel, are and will continue to be a great resource to both the Department and Bureau of Reclamation modeling staff. We do not, however, believe conducting a peer review of the response is an effective use of the Department's staff resources.

Several of the concerns within your letter relate to the uncertainty in future conditions that may affect water supplies, such as levee failures in the Delta, climate change, or declines in the population of Delta fishes. Information relevant to these factors is evolving rapidly but has not reached a level at which it can be quantitatively incorporated into delivery projections of the SWP. The Department is working on two projects that will improve our ability to make qualitative or quantitative statements about the reliability of conveyance across the Sacramento-San Joaquin Delta. The first is the Delta Risk Management Strategy, which will assess risks to the Delta from floods, seepage, subsidence, and earthquakes; evaluate the consequences of levee failure; and develop recommendations to manage the risk. The second is a broader public process to develop a shared vision of a sustainable Delta that continues to support societal needs related to recreation, land use, water supply, transportation, energy, and environmental health. This Delta Vision process incorporates the requirements of AB 1200, passed by the legislature and signed by the Governor in 2005. None of these efforts will be completed before release of the next Reliability Report, but they may yield some preliminary results and conclusions in time for the next report, and will be fully incorporated into subsequent Reliability Reports.

Ms. Mindy McIntyre
April 20, 2006
Page 3

As directed in the Governor's Executive Order S-3-05, the potential impacts of climate change are being analyzed. This effort and the results referenced in your letter are broad brush estimates of the potential impact upon the SWP 50 to 100 years into the future if no additional conveyance facilities or upstream reservoirs are built. This information is helpful in developing strategies for the future management and development of the State's water resources, including improvements to the SWP. The Department does not want to leave any reader of DRR (2005) with the impression that this developing information is being ignored. Therefore, the final report has been modified accordingly.

You comment that information planned to be used in the draft DRR (2005) should not have been given to the State Water Contractors in the spring of 2005 for incorporation into their Urban Water Management Plans. The Department provided the contractors results of the analyses planned to be used in the draft report because they were the best information available at that time. The information was conveyed in the Notice to State Water Project Contractors No. 05-08 as an excerpt from the draft technical chapter of an incomplete draft report. There was no intent of the Department to exclude this information from the public. This notice was not announced on the Department's Home page but all State Water Project Contractors' Notices are available at http://www.swpao.water.ca.gov/deliveries/. As soon as the Department learned that you wanted a copy of this information, it was provided to you. It is the Department's responsibility to provide the best available information to water supply contractors of the SWP.

You make the point that the report should be available to the public as a draft and finalized prior to deadlines for local agency Urban Water Management Plans. The Department agrees with this comment. It is unfortunate that the review of the draft report and completion of the final report could not be done in late 2004 or early 2005 for full incorporation into Urban Water Management Plans. The objectives of the Department for the Reliability Report are to encourage public discussion and understanding of the estimation of the SWP delivery capability, meet the conditions of the settlement agreement, and provide the best available quantification of SWP deliveries. Given the situation, the Department chose to provide the information to the contractors, as described above, and to delay the completion of the report to allow public review of a draft. The next time the Reliability Report is due in the same year as the Urban Water Management Plans, the Department will strive to complete it as early in the year as possible.





Ms. Mindy McIntyre
April 20, 2006
Page 4

Your letter also makes the observation that the percentage of time the assumed demand is met decreases as the level of demand increases. This is correct. The results contained in the draft DRR (2005) are shown as percentages of the maximum Table A amount so the information can be easily interpreted by SWP contractors and incorporated into their analyses. Presenting the information as a percentage of the assumed demand would require additional calculations and would increase the potential for misinterpretation. For example, with the data presented as a percentage of the maximum Table A amount, a contractor can take this percentage and apply it to the specific maximum Table A amount for his or her district to determine how much water would be available to the district. If the information were presented as a percent of the demand, the amount of water that it equates to must be determined by referencing the assumed demand for a specific year and then calculating the amount of water associated with it. Attachment 1 is a plot of the results of the draft DRR (2005) as percentages of the assumed demand. It confirms your observation that the percentage of time the assumed demand is met decreases as the level of demand increases.

Your letter recommends the report include scenarios for future SWP demands that reflect the approach taken in the current California Water Plan. The Water Plan includes estimates for California's water demands which assume a continuation of current trends, a less intensive use of water, and a more intensive use of water. As noted in the Water Plan, the scenarios presented there are for demonstration of the kind of scenarios that should be looked at in more detail once the analytic tools are developed. The Department will undertake an effort to define a range of future demand scenarios for the SWP. This effort will not only provide information for future delivery reliability reports but also for the next Water Plan. As a point of clarification, your letter refers to the Tulare Lake hydrologic region analyzed in the Water Plan as an SWP service area. A few of the SWP agricultural contractors are in the Tulare Lake hydrologic region. Their service areas occupy a portion of the hydrologic region. The region is much larger than these service areas and includes the cities of Fresno, Visalia, and Bakersfield.

You express a concern about the consistency of the studies in the draft DRR (2005) with the description of the operation of the SWP in the Operations Criteria and Plan (OCAP), upon which the current biological opinions for the SWP and Central Valley Project are based. Studies 4 and 5 of the draft DRR (2005) use the same version of CalSim-II as the OCAP analyses and are, therefore, consistent with the OCAP project description. The Table A and Article 21 demands of the studies are within the range of the OCAP project description. If regulatory standards are modified in the future, the model will be updated to include any modified standards.

Ms. Mindy McIntyre
April 20, 2006
Page 5

Your letter states that Article 21 should not be recommended as a supply to be integrated as a firm annual supply in planning documents. This comment is regarding the examples shown in Chapter 6 which illustrate how to calculate water supplies from the information presented in the report. In response to your concern, a footnote alerting the reader to the variability of Article 21 deliveries and referring back to the discussion in Chapter 5 has been added to the tables addressing average values. Chapter 5 thoroughly discusses the limitations of Article 21 supply.

The final report will be issued soon and will include an appendix containing the comment letters on the draft report and the Department's responses. Thank you for your comments and recommendations. If you wish to discuss this report further, please contact me at (916) 653-1099 or kkelly@water.ca.gov. Francis Chung, Chief of the Modeling Support Branch of the Bay-Delta Office, should be contacted for technical questions on the CalSim-II modeling studies. He may be reached at (916) 653-5924 or chung@water.ca.gov.

Sincerely,

***Original signed by***

Katherine F. Kelly, Chief
Bay-Delta Office

Attachments

cc: (See attached list.)





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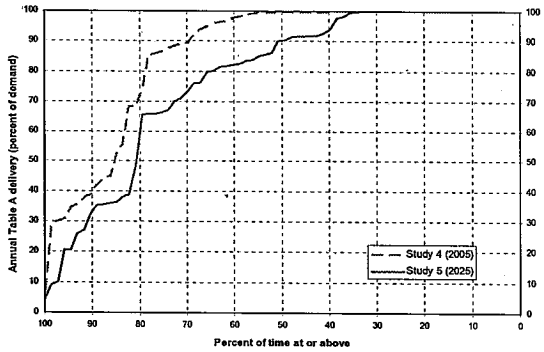
Attachment 1
Planning and Conservation League

**SWP Delta Table A delivery probability**
**for studies 4 and 5**
**as percent of Table A demand**




**Study 4** simulates a variable Table A demand of 2.3 – 3.9 million acre-feet (MAF) per year, dependent upon water-year type.

**Study 5** simulates a variable Table A demand of 3.9 – 4.1 MAF/year, dependent upon water-year type.

Attachment 2
Response to PCL

**Responses to comments from Planning and Conservation League (December 22, 2005) on Draft State Water Project Delivery Reliability Report – 2005**

**Responses to comments on the adequacy of CalSim-II**

**Comment: CalSim-II has not been calibrated or validated.**

**Response:** CalSim-II is essentially a continuous accounting model, supplemented by a linear programming module to optimize the monthly operation of the system without foresight about the conditions in the next period. The primary physical law governing the simulation procedure is conservation of mass, maintaining a mass balance from one period to the next, while optimizing allocations of the available water in that period without foresight about the future periods of simulation. Models such as CalSim-II are inherently different from models that simulate hydrologic processes based on the physical laws governing the precipitation-runoff and the physical routing of water through a system of channels with defined geometry, roughness, streambed slope, etc. The classical model calibration process is difficult to apply to planning models, such as CalSim-II, that are primarily used to predict operations and water availability for a fixed level of development in the future. Continuing development of new supplies, along with changes in demands and the regulatory environment have all resulted in considerable changes to the management of the Central Valley Project (CVP)/State Water Project (SWP) system in the past 35 years. Project operations to meet future demands are often predicated on operation rules, storage and conveyance facilities, and demand levels which are necessarily different from historical conditions.

Although classical approach to model calibration can not be applied to models like CalSim-II, calibration of some of the important components of the model is possible, and has been done. For instance, one of the most important components of the model, its hydrologic component, has been calibrated by including closure terms in the form of local surface water accretions from every depletion study area (DSA) of the model network to match the historically available stream gage records. The routine used to determine the Sacramento River flows and the corresponding Delta exports that meet Delta water quality standards, is an Artificial Neural Network (ANN) model that is trained using the calibrated Delta Simulation Model (DSM2) prior to being used in CalSim-II simulation runs. Also, a revised groundwater-surface water interaction module is currently being developed that uses groundwater-surface water response functions produced by the simulation of the historical groundwater pumping

1





Attachment 2
Response to PCL

amounts that match the available historical data on groundwater levels and stream gage data. The above components of CalSim-II, that are either directly or indirectly calibrated, are three of the most important components of the model that have the most significant impacts on the simulation results, and as such, it would be inaccurate to claim that CalSim-II has not been calibrated. In the absence of a classical approach to calibration applicable to complex models like CalSim-II, the next best approach is generally to set model parameters for a simulation run relying on experience and then verifying the results of the simulation run by comparing to historical operations. To verify model results, the Department of Water Resources (DWR) conducted a 24-year simulation using historical input from 1975 to 1998. The results of this study showed remarkable matching of the simulated values of the major components of system operation to historical values. Components such as stream flows at key locations and the net Delta outflow index showed little difference between simulated and historical values. Therefore, it would be inaccurate to claim that CalSim-II has not been validated. For detailed examination of the validation study the reader is referred to *CalSim-II Simulation of Historical SWP/CVP Operations, Technical Memorandum Report*, November 2003.

**Comment: It is unclear whether CalSim-II incorporates limitations to groundwater use in the Sacramento Valley.**

**Response:** The issue of over-estimation of the water available in the Delta as a result of excessive pumping of groundwater in the Sacramento Valley was examined in the *CalSim-II Simulation of Historical SWP/CVP Operations, Technical Memorandum Report*, November 2003, and addressed in the *Peer Review Response* report of August 2004. The results of the simulation indicated that CalSim-II, in fact, under-estimates the long-term contribution of the groundwater when compared to the historical groundwater pumping in the Valley, and only slightly over-estimates this contribution in extended drought periods. The *Peer Review Response* report states:

> "The mix of surface water and groundwater used by the model to meet Sacramento Valley consumptive demands depends primarily on project water allocation decisions and levels of minimum groundwater pumping that are specified in the model. Over the 24-year period average annual net groundwater extraction in CalSim-II as compared to estimates based on the Central Valley Groundwater Surface Water Model (CVGSM) is lower by 378 thousand acre-feet (taf). The average annual net stream inflow from groundwater in CalSim-II is 190 taf greater than estimated by the CVGSM for the same period. The combined effect of dynamically modeling groundwater operations in CalSim-II (pumping, recharge and stream-aquifer interaction) leads to 188 taf per year less water being available to the Delta. For the 1987-92 period the combined effect results

2

Attachment 2
Response to PCL

in 46 taf per year additional water being available to the Delta. Thus the Historical Operations Study concludes that the current representation of groundwater in CalSim-II results, on average, in an under-estimation of water available at the Delta."

For more details on how groundwater-surface water interaction is modeled in CalSim-II, the reader is referred to pages A-2 and A-3 of the *Peer Review Response* report. As mentioned above, a revised groundwater-surface water interaction module is currently being developed and will be implemented in CalSim-III to use groundwater-surface water response functions produced by the simulation of the historical groundwater pumping amounts that match the available historical data on groundwater levels and stream gage data.

**Comment:** **The CalSim-II model should not be used to make absolute predictions, such as those incorporated into the Reliability Report.**

**Response:** It is true that a planning model like CalSim-II is best used in the comparative mode, when a "without project" scenario is compared with a "with project" scenario. However, this does not preclude the use of this model in studies like the ones used in the Delivery Reliability Report, provided that the users are sufficiently aware of the model assumptions and how to use the output data that CalSim-II simulations provide. The conversion of raw output data to usable information in planning studies requires judgment by the user. As discussed earlier, in the response to comments on the validation efforts by the Historical Operation Study, CalSim-II does very well in mimicking historical operations as evident by the comparisons made on the key system operation components. Furthermore, the reader is referred to the general comments made by the CALFED peer review panel in the executive summary of their December 2003 report. The panel proposes the following question: "Is the general CalSim modeling approach appropriate for predicting the performance of the general facilities and for use in allocation planning, assessing water supply reliabilities and for carrying out operational studies?" The panel's answer to this question is: "We believe the use of an optimization engine for simulating the hydrology and for making allocation decisions is an appropriate approach and is in fact the approach many serious efforts of this kind are using. It is a substantial improvement of the previous modeling approaches and provides a basis for consensus among federal and state interests. The modeling approach addresses many of the complexities of the CVP/SWP system and its water management decisions."

3





Attachment 2
Response to PCL

**Comment:** **CalSim-II does not recognize or report uncertainty.**

**Response:** Recognizing and addressing uncertainties in the CalSim-II simulations is an important issue that has been under consideration by the DWR and Bureau of Reclamation model development teams. After several discussions with the experts in the area, a research project is planned as a joint effort of DWR and the University of California at Davis to further investigate ways to identify and address uncertainties.

In addition to the planned joint effort with the UCD, DWR has recently completed the CalSim-II sensitivity analysis study focusing mainly on the Sacramento Valley hydrology, Sacramento-San Joaquin Delta water quality, and SWP operations. As a supplement to the sensitivity study, DWR will conduct a more focused statistical analysis of the impact of model input parameters on the modeled SWP.

**Comment:** **CalSim-II may produce "cyber water."**

**Response:** This comment does not indicate how the 75 percent exceedance level was estimated for the 2001 water supply. From the comments made later in Appendix A, it appears to refer to the Sacramento Valley water year index values for the period 1922 to 1994. The Sacramento Valley water year index data alone would not provide an accurate estimate of the capability of the SWP to deliver water since it does not consider project storage. Deliveries to the SWP south-of-Delta contractors in CalSim-II are not based on the Sacramento River Index, but on the storage in the SWP conservation facilities, Lake Oroville and SWP portion of San Luis Reservoir, the forecasted inflow to Lake Oroville, and other unregulated flows and accretions. Based on Figure 5-1 of the report, an annual delivery of 1.6 million acre-feet (maf) or more would occur in 85 percent of the years.

4

Attachment 2
Response to PCL

**Responses to Comments in Appendix A**

**First comment regarding page 7 of the draft report**

**The report should highlight the weaknesses in the analysis and put the referenced statement in a text box.**

The final Report (2005) has been modified to expound upon uncertainties associated with the analyses. Many of these modifications have been done in response to the comments of the PCL. We believe the final report sufficiently addresses the uncertainties associated with the projections.

**Second comment regarding page 7 of the draft report**

**What analysis of current or future demand patterns is used to justify the assumption of a demand for full Table A allotments?**

As stated on page 15 of the draft report, "The assumed demands for studies 4 and 5 were developed in discussions with SWP water contractors and stakeholders involved in the development of the analyses associated with the environmental documentation for the Monterey Agreement." SWP contractor's Table A requests for the real-time operations are developed and submitted to DWR by contracting agencies and their consultants. Examination of the historical requests show an increasing trend and they reach the full Table A request of 4.1 maf in 2001. As the following table indicates, contractors' requests were at full Table A amounts in 5 out of the 6 recent years.

5





Attachment 2
Response to PCL

| Year | SWP Contractor's Table A Request (maf) |
|---|---|
| 1986 | 2.4 |
| 1987 | 2.7 |
| 1988 | 2.6 |
| 1989 | 3.0 |
| 1990 | 3.1 |
| 1991 | 3.5 |
| 1992 | 3.6 |
| 1993 | 2.7 |
| 1994 | 2.7 |
| 1995 | 3.1 |
| 1996 | 2.7 |
| 1997 | 3.0 |
| 1998 | 3.2 |
| 1999 | 3.2 |
| 2000 | 3.6 |
| 2001 | 4.1 |
| 2002 | 3.9 |
| 2003 | 4.1 |
| 2004 | 4.1 |
| 2005 | 4.1 |
| 2006 | 4.1 |

6

Attachment 2
Response to PCL

**Third comment regarding page 7 of the draft report**

**Statement: The following statement should be clarified or removed.**

"Conversely, the current or projected delivery capability of the a water project would be less if (1) demand for water from a water project was at its maximum level for many years, (2) no new facilities were built, and (3) the supply of the main sources of water was recently reduced because another entity with a prior water right increased its use of that source."

The statement is revised as follows:
"Conversely, the projected deliveries of a water project would be less than the past if the water project had been operated at its maximum ability for many years, no new facilities were planned to be built, and the annual supply from one of its main sources of water was recently reduced and would remain at the reduced level."

**Comment regarding page 8 of the draft report**

**The results of sensitivity analysis are not included in the report.**
(See response to the last comment in this appendix.)

**Response to comments regarding page 11 and page 74 of the draft report**

**Historical Operation Study as a means to validate CalSim-II**

An objection is raised in Appendix A of the letter to the Department's claim that the results of the Historical Operation Study validate the CalSim-II model as an appropriate tool for planning studies. The specific objection seems to be to the statement in the Delivery Reliability Report, page 11 that states "The simulated deliveries in Figure 3-1 were adjusted for any differences between the historical and simulated carryover storage in the SWP system reservoirs, Lake Oroville and SWP's portion of San Luis Reservoir." The letter from the Planning and Conservation League raises the objection that "If the storage levels in SWP reservoirs were not faithfully reproduced and had to be adjusted in some unexplained way to generate the results in Figure 3-1, then the Technical Memorandum should not be used to build the credibility of the CalSim-II."

7





Attachment 2
Response to PCL

The detailed explanation of how and for what purpose the deliveries were adjusted to produce Figure 3-1 was deemed to be out of the scope of the 2005 update of the Delivery Reliability Report and the reader is referred to the Technical Memorandum Report, pages 18 and 19, for further detail. In summary, the resulting simulated annual deliveries during the 6-year drought of 1987-92 were adjusted by post-processing to account for the differences between the historical and simulated initial and end-of-year storages in the SWP system reservoirs. The adjustments were made to show the resulting year-to-year deliveries had the model's delivery for that particular year reflected identical use of stored water from the SWP reservoirs. In both the adjusted and the unadjusted case, however, the average annual delivery during the 6-year drought was 1,930 taf per year. The following table and the attached charts (Figure 1 for the unadjusted simulated deliveries, and Figure 2 for the resulting deliveries after adjustments) should clarify the post-processing procedure.

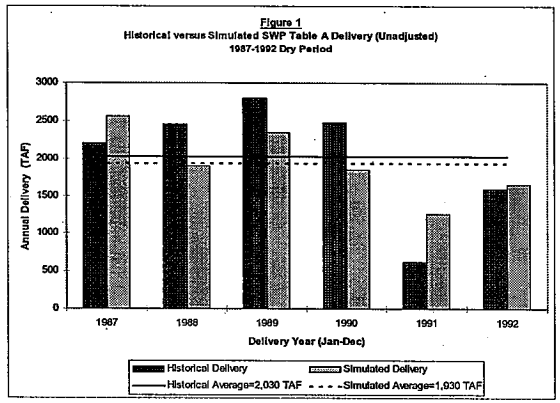
| Calendar Year | Simulated SWP SOD Deliv (TAF) | Simulated January 1 Storage (TAF) | Simulated December 31 Storage (TAF) | Simulated Storage Withdrawal (TAF) | Historical Storage Withdrawal (TAF) | Storage Withdrawal Adjustment (Historical-Simulated) (TAF) | Adjusted Delivery (TAF) |
|---|---|---|---|---|---|---|---|
| 1987 | 2567 | 4120* | 2634 | 1486* | 1182* | -304 | 2263 |
| 1988 | 1903 | 2634 | 2026 | 608 | 1050 | 442 | 2345 |
| 1989 | 2350 | 2026 | 2635 | -609 | -597 | 12 | 2362 |
| 1990 | 1851 | 2635 | 1738 | 897 | 1512 | 615 | 2466 |
| 1991 | 1266 | 1738 | 1730 | 8 | -682 | -690 | 576 |
| 1992 | 1652 | 1730 | 1748 | -18 | -110 | -92 | 1560 |
| **Average**** | **1930** | | | | | | **1930** |

* This storage and the corresponding withdrawals are from April 1, 1987 to December 1987, because the 6-year drought is assumed to have started from April 1, 1987, the last month before the onset of the drought in which the system's reservoirs were full.

** Rounded off to the nearest 10 taf.

8

Attachment 2
Response to PCL

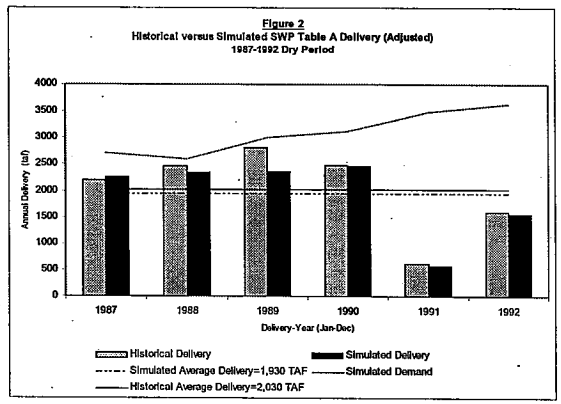



9





Attachment 2
Response to PCL




The simulated month-to-month operation of the system may vary substantially from the actual historical operation, although the long-term average flows and deliveries are typically close. Therefore, post-processing of some of the raw data resulting from the simulation run is sometimes necessary to account for some of the unavoidable differences between the historical and simulated results. Some of the factors that could contribute to these differences in the month-to-month operation are:

- Delivery versus carryover storage rules
- Delta outflow requirements to comply with SWRCB standards
- South-of-Delta demand assumptions
- Level of north-of-Delta groundwater pumping
- Rule curves to transfer water from north-of-Delta reservoirs to San Luis Reservoir
- Crop consumptive use of applied water and agricultural water use efficiency
- Assumptions on historical land use, and project versus non-project demands
- Stream-aquifer interactions

10

Attachment 2
Response to PCL

- Historical operation based on decisions that are made in shorter time resolutions that the monthly simulation model captures, such as flood control operations, hydropower operations, export curtailments due to fish take limits, system scheduled and unscheduled outages, etc.
- CVP reservoirs balancing north of Delta
- Compliance with the provisions of the Coordinated Operations Agreement
- Drought water bank and water transfers

The following summary should be helpful in determining how well the Historical Operation Study was able to reproduce the actual historical records on the key components of the system operation. Figure 10 on page 46 of the Technical Memorandum Report shows that the simulated long-term average SWP delivery to the south-of-Delta contractors exceeded the historical average delivery by only 1.1 percent. Figure 12 on page 48 (same as Figure 2 in this response) shows that the simulated average annual delivery in the 1987-92 drought was less than the historical average delivery by 4.9 percent. Figure 26 on page 62 shows that the total project exports from the Delta during the 6-year drought was less than the historical average by only 0.2 percent. Figures 31 through 35 on pages 67 through 71 show that the simulated average annual flows in various key locations along the Sacramento River vary from the historical values by 0.5 percent to 4.5 percent. Figure 37 on page 73 shows that the simulated long-term average annual net Delta outflow index is less than the historical value by 3.1 percent. There were many other simulated variables that were compared to their historical values in the Technical Memorandum Report that reflect a more complete picture of how well CalSim-II was able to mimic historical operations. These results, of course, should be examined carefully with an eye on what caused the variation, and how significant the variations were. In other words, how close is close enough to validate CalSim-II as an appropriate model in long-term planning applications, and whether the model reflects the historical record on important system performance measures with sufficient accuracy.

**Response to comment regarding page 16 of the draft report**

**Updated Article 21 demand should be explained.**

The demand for Article 21 water is submitted to DWR by the contracting agencies and the increase of 50 taf in December through March is due to the increased requests submitted to DWR by the Metropolitan Water District of Southern California.

11





Attachment 2
Response to PCL

**Responding to comment regarding page 25 of the draft report**

**There is nothing special about the thresholds used to reference the curve in Figure 5-2. They should be changed as recommended.**

The percentages of 75, 50, and 25 are chosen as simple examples to illustrate how to read the curve. These percentages are at or near the mid-range of the curve and the results are surrounded by several data points. Using the end points of the curve for an illustration is not as effective and, in the case of the lowest delivery value, focuses on the result for a single year.

**Response to comment regarding page 26 of the draft report**

**DWR's attempt at post-processing 1976-77 deliveries is not valid**

As stated on page 25 of the draft report, CalSim-II is a planning model and is best used for estimating SWP performance over long periods of time. Considerable judgment should be applied when evaluating CalSim-II results for shorter periods of time. This is especially true for estimates for the single driest year on record in a 73-year sequence.

**Response to comment regarding page 49 of draft report**

**It is inappropriate to speculate on what deliveries will be with new facilities.**

The paragraph is deleted.

**Response to comment regarding page 78 of the draft report**

**Results of the sensitivity analysis should be applied to interpreting the results of the reliability analysis.**

The Sensitivity Analysis Study is discussed in the draft report to inform the reader of the status of DWR's commitment to conducting such a study. The sensitivity study will be further analyzed in view of the SWP Delta deliveries and the results of that analysis will be incorporated as appropriate in the next Reliability Report.

It should be noted that the summary results on SI and EI shown in the Table E-1 are strictly applicable to the long-term (1922-1994) performance of the project. It is not appropriate to apply these results to a single year. In addition, these results should be applied with caution since they are applicable only within the investigated range of variation of the input parameters. The sensitivity study analyzed the response of the SWP total and Delta delivery for a 5 percent reduction in the Banks pumping capacity and ±5 percent variation in Oroville inflow.

12

California Department of Water Resources
SWP Reliability Report-Attn: Johnnie Young-Craig
P.O. box 042836
Sacramento, CA 94236-0001

December 19, 2005

Subject: The State Water Project Reliability Report 20005—Draft

Dear Sirs:

The report informs us that it is an update to the 2002 edition of the report of the same name. The foreword states that DWR will update this information every 2 years. However, the Department of Water Resources is derelict in not acknowledging that this report is a requirement of the amendments to the SWP contracts that was agreed to in the settlement negotiations pursuant to the Monterey litigation.

**Purpose**

The report is not simply information to help the contractors understand to what degree they can rely on SWP deliveries, but in fact is an essential requirement stemming from the need to eliminate "paper water" from the contracts. The Appellate Court was clear on the problems in planning that proceeded from the previous interpretations allowed by DWR that in effect created the notion of "paper water." In the settlement negotiations it was made clear that a well documented and unambiguous report of delivery reliability was essential to the elimination of "paper water." Accordingly, this report must be reviewed with that primary objective in mind.

Does the report fulfill that purpose? Its self-defined scope certainly allows for that possibility, but without serious calibrations of the main analytic tool, CALSIM II, used to perform the analysis, it is doubtful that it can. This deficiency has been pointed out many times over the past several years and DWR has still failed to come to grips with it. Their limited study, whose results are summarized in the draft, do little to meet the requirements of a legitimate calibration. Calibration, properly done, allows the program developers to assure that all elements of the computer program work properly. In the case of CALSIM II the calibration will show from where in the operational regimen of the SWP the increased amounts of water it predicts will materialize. Even the Scientific Peer Review Committee stated as much; they noted without a proper calibration there is no assurance that the results that are calculated from an optimization routine are a real solution. They must be shown to conform to realistic operations that are known to be feasible. No where in the report is this demonstrated or even hinted at.

**Previously Noted Deficiencies**

The lack of calibration and other deficiencies have been made known the DWR in formal comments on the 2002 draft. On reading this draft there seems to be no acknowledgement that any of these deficiencies have been addressed. The list of these previous deficiencies is highlighted below.





1.). The frequency diagrams are without statistical merit and therefore cannot be used to provide estimates of "reliability."

2.) The draft continually refers to CALSIM II as a "simulation." Until CALSIM II has been calibrated to show that it conforms to a real and feasible operational regimen, its results cannot be interpreted as though it is a simulation. Even then, its computerized configuration is not even close to what is ordinarily referred to as "simulation." CALSIM II is an optimization model in which the objective function is to maximize exports of water from the Delta given certain constraints. In typical optimization models not all solutions are feasible. Only calibration can establish that possibility. This model does not meet that criterion.

3.) The model makes certain assumptions about the individual contractors' demand for SWP deliveries. Those demand functions have not been vetted against the realistic capabilities of each contractor to take SWP water. In one case the assumption is factually wrong- San Luis Obispo County physically cannot take its full Table A amount of 25,00 acre feet because it is limited by physical capacity of the SWP pipeline to only 4800 acre-feet. Nonetheless, the model assumes that SLO County will take 25,000 acre-feet when it is available at the Delta. Also there are some contractors that are unable to take their full Table A amount simply because they don't have the proper amount of equalizing storage to take the water when the SWP says it is available. The demand functions have not taken these and many other considerations into account. Because the model is an optimization against these demand functions the results cannot be taken at face value until the demand functions have been made realistic in terms of the requirements of the individual contractors.

4.) The report uses a definition of reliability that follows from their construct -ion of the frequency charts they use to summarize the results. When they state for example that the project can deliver 73% reliability, that is an incorrect interpretation of the data in the chart. In fact, the point at which 73% of the Table A water is delivered is actually the 50% point in the frequency chart. The correct statement would be: The project can deliver 73% of the water 50% of the time. However, this is not quite true either because the frequency charts are not statistically valid and insufficient to support an estimate of delivery reliability.

**Additional Deficiencies**

There are also some additional deficiencies that have since been revealed through careful studies of the CALSIM II model. These have to do with the assumptions on constraints and some fundamental errors in the statistical basis of the model's inputs.

The model exercises for this report assume that SWRCB rules that operate to constrain export pumping will continue unchanged into the future. If the model results showed that future export pumping would continue at about the same level, that may perhaps be a defensible assumption. However, we have the case where the model results show that on average future export pumping will be 50% greater than the recent historical average under most all anticipated hydrologic conditions. Given that result it would seem prudent to examine to what degree SWRCB rules might be modified in anticipation of the environmental damage to be expected with such an increase in export pumping. The model does not do that. In fact, before these results can be used by anyone, the model's calculations should be explored to discover where and to what degree existing historic pumping regimens are expected to change. After all, the existing rules were developed in response to concerns with the operational problems that were demonstrated along the way during historic pumping. The rules certainly cannot be interpreted as definitive statements on what is acceptable for the Delta environment irrespective of the levels of export in the future.

The model also uses a sub-model to calculate the movement of the X 2 salinity threshold in the Delta as a function of hydrologic conditions. Unbelievably the sub-model calculational routine does not include the level of pumping. It is difficult to believe that the movement of the salinity threshold is independent of export pumping. Furthermore, given that CALSIM II predicts a 50% increase in exports over historic levels it would seem prudent to examine whether this simple routine is really applicable at that higher level. The research that went into the development of this calculational routine should be peer reviewed. The same may be said with the entire modeling of cross Delta transport calculations.

Perhaps the greatest problem with CALSIM II is its total disregard for proper statistical analysis in the development of the model. It is easy to verify that the input hydrology to the model represents a complex statistical distribution. In fact, it is what is referred to by statisticians as "bi-modal" meaning there are two main modes. One significant consequence of this feature is that the grand average of the total 73 year record is a very unlikely occurrence. All references in the report to average deliveries over 73 years are totally misleading.

The two modes clearly depict a collection of dry years and another of wet years. There are slightly more cases of dry years than wet ones although for practical purposes they are roughly equal. It is also the case that except for droughts there is virtually no serial correlation year-to-year. This means that a wet year may be followed with equal likelihood by either a dry or wet year. The fundamental problem that SWP operators must continually face is under what conditions is it prudent to pump given uncertainty in what kind of year the project will face. It is a classic operations research problem and involves tradeoffs between the objective of pumping water and the risk that too much will be taken. This operational problem is faced at the beginning of every water year beginning in the fall. A careful study of historic input flows from the Sacramento River in the fall and winter shows that it may be difficult to establish until late in January if the water year will likely be wet so as to allow higher levels of pumping. But a careful examination of SWP pumping capacity shows that the pumps must run at nearly maximum capacity for most of the year if export flows near 4 MAF are to be realized. Clearly, if the 73 average predicted by this model is near 4 MAF then we must assume that heavy pumping is





allowed during the fall and winter months before it is known that the year will indeed be wet. How is this reconciled with prudence and so call risk avoidance?

Because the model incorrectly deals with the statistical nature of the input hydrology it also includes some totally improper inputs. The model relies on a "water year index" which is a convolution of the spring and fall/winter runoffs across years. The affect is to produce an index which is uni-modal in contrast to the bi-modal hydrologic input. Because there is no significant year-to-year correlation in runoff, this convolution is without scientific merit and totally distorts the basic operational decision problem so that it no longer represents any reality. Furthermore, this water year index is further convoluted to a "water year type" designator that is used to establish Delta export/inflow ratios that ostensibly are used to protect the Delta environment.

The "water year type" is the index that is used in the CALSIM II model to establish what the required outflow in the Delta must be to satisfy the SWRCB rules. It is used in the model by a "lookup table" that predetermines the water year before it is fully developed. It does this by combining the previous spring's runoff with the current fall and/or winter runoff to decide whether the coming water year is going to be wet or dry. Needless to say, the statistical nature of the runoff record defies predicting what the upcoming water year will be. But by this simple mechanism the model is given fore knowledge of conditions before they are experienced. This departs radically from any notion of simulation. The convolution giving rise to this "water year type" has no demonstrable logical analysis for its existence. Clearly, the CALSIM II model cannot be taken as a valid model until some of these logical flaws are explained or corrected. By extension, the Reliability Report is without any scientific merit and is virtually useless for the purposes stated.

**Additional Inconsistencies**

There are additional problems that deserve explanation beyond what is stated in the Reliability Report. When one compares the set of tables documenting the past 10 years of deliveries to the various contractors and compares them to the same years reported in the 2002/2003 version there are some significant changes. Out of the ten years only one of the years appears to be the same in the two volumes. Most of the changes in deliveries seem to occur in the values reported for Kern Co. and Castaic Lake Water Agency. The latest report should explain these differences.

Sincerely,

Arve R. Sjovold

Plaintiff CPA Representative
In the Monterey Settlement
Negotiations

Plaintiff CPA Representative
To Monterey ++ EIR Comm.

RETURN ADD:

186 SIERRA VISTA
SANTA BARBARA, CA
93108

STATE OF CALIFORNIA -- THE RESOURCES AGENCY

ARNOLD SCHWARZENEGGER, Governor

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

January 30, 2006

Mr. Arve Sjovold
186 Sierra Vista
Santa Barbara, California 93108

Dear Mr. Sjovold:

This letter responds to your letter dated December 19, 2005 commenting on the Draft State Water Project Delivery Reliability Report (Report 2005). Your comments have been thoroughly reviewed and the recommended changes considered and incorporated as appropriate.

Most of your comments are regarding the suitability of the CalSim-II computer simulation model for estimating the delivery reliability of the State Water Project (SWP). You state that the use of CalSim-II is inappropriate due to the lack of calibration and other deficiencies as identified in comments on the *State Water Project Delivery Reliability Report 2002 (2003)* and mentioned in the peer-review report, *A Strategic Review of CalSim-II and its Uses for Water Planning, Management, and Operations in Central California* (Close and others 2003). Many studies conducted by the Department of Water Resources (DWR), self-initiated or in response to public questions or criticisms, support the conclusion that CalSim-II provides a reasonable simulation of SWP operation and is a useful tool for assessing the delivery capability of the SWP.

The CalSim-II studies provide quantitative estimates of reliability based on historical rainfall and runoff data under the assumption that reliable conveyance capability will continue into the future. As we know, the Delta is a very dynamic environment. DWR is working on three projects that will improve the ability to make qualitative or quantitative statements about the reliability of conveyance across the Sacramento-San Joaquin Delta. These include: the Delta Risk Management Strategy, which will assess risks to the Delta from floods, seepage, subsidence, and earthquakes, evaluate the consequences of levee failure, and develop recommendations to manage the risk; implementation of AB 1200 (Laird, 2005) which calls for a similar evaluation of impacts on water supplies from catastrophic Delta failure; and a broader public process to develop a shared vision of a sustainable Delta that continues to support societal needs related to water supply, transportation, recreation, land use, energy, and environmental health. These efforts will not be completed before release of the next Reliability Report, but may yield some preliminary results and conclusions by then. Our intent is to fully incorporate this information into subsequent Reliability Reports.







The final Report 2005 includes a discussion of these uncertainties and a commitment to incorporate the above-mentioned information as it evolves. The final report also includes a statement regarding the report being required per the settlement agreement to the case *Planning and Conservation League v. Department of Water Resources* (2000) 83 Cal. App. 4th 892.

Responses to the specific technical comments you make regarding CalSim-II are attached.

The final report will be available soon and will include an appendix containing copies of all commenting letters accompanied with the Department's responses. If you wish to discuss this report further, please contact me at (916) 653-1099 or kkelly@water.ca.gov. Francis Chung, Chief of the Modeling Support Branch of the Bay-Delta Office, should be contacted for technical questions on the CalSim-II modeling studies. He may be reached at (916) 653-5924 or chung@water.ca.gov.

Sincerely,

Katherine F. Kelly, Chief
Bay-Delta Office

Attachment

cc: Francis Chung, Chief
Modeling Support Branch
Bay-Delta Office
1416 Ninth Street, Room 252-6
Sacramento California 95814

1. **CalSim-II has not been calibrated or validated.**

Models such as CalSim-II are inherently different from models that simulate hydrologic processes based on the physical laws governing the process that is being modeled. Although a classical approach to model calibration can not be applied to models like CalSim-II, calibration of some of the important components of the model is possible, and has been done. For instance, one of the most important components of the model, its hydrologic component, has been calibrated by including closure terms in the form of local surface water accretions from every depletion study area of the model network to match the historically available stream gage records. The routine used to determine the Sacramento River flows and the corresponding Delta exports that meet Delta electrical conductivity standards is an Artificial Neural Network (ANN) model that is trained using the calibrated Delta Simulation Model (DSM2) prior to being used in CalSim-II simulation runs. Also, a revised groundwater-surface water interaction module is being developed that uses groundwater-surface water response functions produced by the simulation of the historical groundwater pumping amounts. The above components of CalSim-II, which are either directly or indirectly calibrated, are three of the most important components of the model that have the most significant impacts on the simulation results. It is, therefore, inaccurate to assert that CalSim-II has not been calibrated.

In the absence of a classical approach to calibration, the next best approach is to set model parameters for a simulation run relying on experience and then verify the results of the simulation run by comparing them to historical operations. To verify model results, DWR conducted a 24-year simulation using historical input from 1975 to 1998. The results of this study showed the simulated values of the major components of system operation matched the historical values very well. Components such as stream flows at key locations and the net Delta outflow index showed little difference between simulated and historical values. For detailed examination of the validation study the reader is referred to *CalSim-II Simulation of Historical SWP/CVP Operations, Technical Memorandum Report*, November 2003.

2. **CalSim-II is an optimization model that has not been calibrated.**

CalSim-II is a simulation model of the Central Valley Project (CVP)/State Water Project (SWP) system. It is a continuous accounting model, supplemented by a linear programming module to optimize the operation of the system for the current period of simulation (a month) subject to physical, operational, and institutional constraints of the system without foresight about the conditions in the next period. It should be noted that although a linear programming module is used as a tool to allocate water subject to all the constraints of the system in that particular month, CalSim-II does not attempt to optimize the overall operation of the system over the 73-year study period, and therefore it is not an optimization model. The issue of calibration of the model has been addressed in item 1,

1





above. The model is not designed to maximize deliveries but to meet the assumed annual requested contractors' demands to the extent possible while meeting all physical and operational constraints. CalSim-II modeled operation has been critically reviewed by both SWP and CVP operators, and they are satisfied with the degree of mimicking actual real world operations done by the model. The CalSim-II model has been used extensively by State Water Contractors and the SWP operation staff to help them develop annual water supply guidelines.

3. **Demand functions have not been vetted against the realistic capabilities of each contractor to take SWP water; case in point San Luis Obispo County.**

It is true that San Luis Obispo County cannot currently take its maximum Table A amount of 25,000 acre-feet. Because of this limitation, their demand in the 2005 level study (study 4) was assumed to be 4,400 acre-feet/year. In the future level study (study 5), however, it was assumed that facilities will have been constructed by the year 2025 to allow delivery of their maximum Table A amount.

4. **The report uses an incorrect interpretation of the data in the chart.**

The proper interpretation of Figures 5-1 and 5-2 is outlined on page 25 of the draft report and the example given for interpreting Figure 5-2 is as follows:

By referencing the curve for study 5 in Figure 5-2, the following can be deduced:

- In 75 percent of the years, the annual water delivery of the SWP is estimated to be at or above 2.70 million acre-feet (maf) per year (65 percent of 4.13 maf).
- In 50 percent of the years, it is estimated to be at or above 3.50 maf per year (85 percent of 4.13 maf).
- In 25 percent of the years, it is at 4.13 maf per year.

5. **The model exercises assume that State Water Resources Control Board (SWRCB) rules will continue unchanged into the future.**

This is correct. The model is based on current SWRCB rules that govern project operations. The Delivery Reliability Report does not speculate on any future modification of the SWRCB rules.

6. **The sub-model does not include the level of pumping as a variable in the relationship that calculates the movement of the X2 salinity threshold.**

First, it is important to note that the level of project pumping in CalSim-II is determined after all Delta requirements, including the outflow to meet the required position of the 2 parts per thousand salinity line (X2), are met. Secondly, the computation of the X2 salinity threshold position in CalSim-II is based on the empirical relationship, developed in a collaborative effort by

2

Wim Kimmerer of BioSystems and Steve Monismith of Stanford University, which is based on observed data. The development process of this relationship and the back-up data were presented and thoroughly examined in the SWRCB hearing process that lead to the Board adopting 1995 Water Quality Control Plan (SWRCB Water Rights Decision 1641). The position of the X2 line in any given month in this empirical model is presented as a function of its location in the previous month and the current month's net Delta outflow. Net Delta Outflow, by definition, includes the total CVP and SWP diversions from the Delta. This relationship has been confirmed to be a good predictor of the movement and position of the X2 line. For more information on this subject, you may refer to the May 18, 1992 memorandum report to the San Francisco Estuary Project by Kimmerer and Monismith, titled *"Revised Estimates of Position of 2 PPT Salinity,"* and Chapter 10 of the June 1994 *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh, 15th Annual Progress Report to the State Water Resources Control Board,* titled "Two Part per Thousand Isohaline Equation Analysis."

7. **The pumps must run at nearly maximum capacity for most of the year if export flows near 4 MAF are to be realized.**

Model results for study 5 show that annual SWP pumping at Banks Pumping Plant would exceed 4 maf in 15 percent of the years. These higher pumping amounts generally only occur in wet years and the average annual SWP pumping at Banks for study 5 is 3.17 maf. The permitted pumping capacity of Banks Pumping Plant is normally 6,680 cfs, although additional pumping above this limit is allowed from December 15 to March 15 whenever the San Joaquin River flow at the Vernalis gage exceeds 1,000 cubic feet per second (cfs). The maximum pumping rate during this 3-month period is 8,500 cfs. Year-round pumping at the lower rate of 6,680 cfs would result in total annual pumping of approximately 4.8 maf. It should also be noted that export pumping is limited to actual demand for water and/or the amount needed to refill storage reservoirs.

8. **Use of the water-year type look-up table predetermines the water year before it is fully developed and this departs radically from any notion of simulation.**

Water Year Type Indices for the Sacramento River basin and San Joaquin River basin are defined in the SWRCB Water Rights Decision 1641. The definition of the Sacramento Valley Water Year Hydrologic Classification is the computation of the following equation:







$$INDEX\ (in\ MAF) = 0.4 * X + 0.3 * Y + 0.3 * Z$$

Where: $X$ = Current Year's April – July Sacramento Valley Unimpaired Runoff

$Y$ = Current October – March Sacramento Valley Unimpaired Runoff

$Z$ = Previous year's Index (With a cap of 10 MAF)

The Sacramento Valley unimpaired runoff for the current water year (October 1 of the preceding calendar year through September 30 of the current calendar year), as published in California Department of Water Resources Bulletin 120, is a forecast of the sum of the following locations: Sacramento River above Bend Bridge, near Red Bluff; Feather River, total inflow to Oroville Reservoir; Yuba River at Smartville; American River, total inflow to Folsom Reservoir. Preliminary determinations of the year classification are made in February, March, and April, with the final determination in May. These preliminary determinations are based on hydrologic conditions to date plus forecasts of future runoff assuming normal precipitation for the remainder of the water year.

D-1641 mandates water quality objectives in and around the Sacramento/San Joaquin Delta Estuary to be met by the SWP and the CVP. Some of these water quality objectives vary according to the water year type of the given year. Real-Time project operators must therefore use the forecast of the water year type from Bulletin 120 in order to determine what level of water quality objectives need to be met. As the water year type forecast is updated, each passing month gives more data of the actual runoff for the current water year and thus firms up the forecast. Also, because the majority of annual runoff occurs in the winter and early spring months, the May forecast is generally very accurate.

CalSim-II uses the historic Water Year Hydrologic Classification Indices for the study period of 1922–1994, rather than the forecasted water year types, in a manner that parallels how the project is operated in real-time. In CalSim-II, the water year type indices do not change for the current water year until February, the same month that real-time operators receive their first forecast of year type. Standards set by in the SWRCB D-1641 for the Delta water quality objectives that vary according to the water year type are mostly specified for months after May. Therefore, the use of the historical water year type index for the Delta water quality objectives in CalSim-II would not be significantly different than how real-time operators arrive at operational decisions about water quality objectives, i.e., using the May forecast of year type. It is important to note that Water Year Type indices are not used in CalSim-II to determine SWP South-of-Delta contractor allocations.

9. **There are significant unexplained differences in the historical SWP delivery data between the last report and the current report.**

There are some minor differences in the historical SWP deliveries between the two reports, ranging from 528 acre-feet to 25,000 acre-feet. These differences come from two sources. The first is the periodic corrections that are made by the DWR State Water Project Analysis Office (SWPAO) in the historical deliveries. The second is the revised procedure by SWPAO to include articles 12d and 14b water types as a part of the Table A delivery in the year that it is requested, rather than the following year when the water is actually delivered to the contractor. In the previous report, amounts associated with these water delivery categories were separately listed and accounted for in the year that they were actually delivered.

5





**ROBERT C. WILKINSON, Ph.D.**
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12/23/05

Lester Snow, Director
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c/o ddeanda@water.ca.gov

cc: Joe Grindstaff, Chief Deputy Director
Department of Water Resources
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Katherine Kelly, Chief, Office of SWP Planning
Department of Water Resources
kkelly@water.ca.gov

**RE: Comments on DWR's Draft Report "The State Water Project Delivery Reliability Report 2005"**

Dear Lester,

I appreciate the opportunity to comment on the department's Draft Report: "The State Water Project Delivery Reliability Report 2005" dated November 16, 2005. I am commenting as an interested citizen, and not on behalf of any institution or organization.

**Overview**

An accurate assessment of the actual amounts of water the SWP can reliably deliver to users under various future conditions is important to the state. This draft report is DWR's second effort to characterize the reliability of the SWP. One might have expected that in light of current discussions (including your own statements) regarding levee failures (by whatever cause), impacts of climate change, vulnerability to "perturbations" ranging from earthquakes to terrorism, and budget and financing challenges, DWR staff would have made further efforts to characterize the range of risks and vulnerabilities affecting the reliability of the SWP. Unfortunately, the reliability report once again places inappropriate confidence in a single computer model as the sole basis for its findings, and it summarily dismisses analysis of these other factors. As such, it does not provide a reasonable representation of the reliability of the SWP for decision-making purposes.

**Importance of the Issue**

Why is an accurate and comprehensive assessment of SWP reliability important? Significant public and private investments are being made in water system infrastructure. More will be needed, as you have argued. Billions of dollars devoted to water systems have recently been approved by voters in bond funding, and more is anticipated

in the future. Thoughtful proposals for revenue streams to service this investment have been advanced, including your own ideas. All of these water system investments are linked to substantial private and public investments requiring reliable water supplies.

As voters weigh the options before them, it is critical that they have an accurate and reasonably complete understanding of the risks as well as the benefits of different options. The report fails to provide the information and analysis needed to properly assess the reliability of the SWP system.

**Risk and Reliability**

The reliability of SWP system deliveries in the future is of course impossible to predict perfectly. It is possible, however, to identify important factors that may impact system performance. The reliability of SWP deliveries will clearly be impacted by issues such as the following:

- Amounts and patterns (time, place, and form – rain/snow) of precipitation and runoff
- Climate change (e.g. impacting flows, timing, temperature, and dam operations for flood control)
- SWP operations impacts on ecosystems and listed species such as the delta smelt
- Reduction of flows into the basin, such as the Trinity River, and changes of flows within the basin
- FERC re-licensing (of Oroville and other facilities)
- Levee failures (due to floods, earthquakes, or other causes)
- Earthquakes impacting key pumping, storage, and conveyance facilities
- Operations of federal and other facilities to meet legal requirements for environmental factors

Issues have also been raised regarding factors that will influence SWP system reliability such as:

- "Take" permits for impacted species
- SWP water rights (vs. extraction and export of "surplus" flows)
- Delta ecosystem impacts

It is not clear that Calsim II is capable of providing a robust and reasonably complete assessment of system reliability, notwithstanding the numerous assertions on the model's behalf provided in the draft report. (I will refrain from reiterating key questions raised in the peer review and elsewhere with regard to Calsim II. Notwithstanding a steadfast assertion by DWR staff that the model is OK, serious problems remain with its use for this type of application.) Some of the issues listed above are factored into the Calsim II analysis at certain levels, others are not. Where they are included, the implications for system reliability are in many cases difficult to determine. It *is clear* that a robust reliability analysis should use more than one method and tool, and that the tools should be properly applied. Additional tools are in fact available to develop a more complete understanding of system reliability.

To suggest that these factors be taken into consideration does not imply that anyone expects DWR to have a crystal ball. Understanding a range of potential reliability factors is useful, and doable. It does not imply a perfect prediction. For example, climate scenarios can provide important information regarding a range of reliability levels under possible future conditions. (Indeed, researchers have undertaken just such studies, including recent ones with Calsim II as the key model for supply reliability analysis. These should be included in the report.)

Disturbingly, in addition to ignoring climate change, the report fails to discuss a number of current issues including: levee integrity and risks related to failure; environmental impacts and issues relating to delta water extractions impacting listed species; and vulnerability of key SWP system components. Nor does it comment on recent decisions in various courts invalidating EIR/Ss dealing with SWP contracts and delta operations. The

2





implications of these decisions, and the eventual environmental analyses, may include important constraints on system operations which would in turn impact system reliability.

**A Comment on Timing**

The 2002 reliability report was "finalized" in 2003. The 2005 report will presumably be finalized in 2006 (comments are due on December 23, 2005). There are two problems with this timing.

The first problem is that the Urban Water Management Plans (UWMPs), required every five years by law, are due in December 2005. Thus, the final SWP reliability report is not available to water managers as input into this important process to evaluate imported water reliability to the retail agencies served by the state contractors. (Though a draft document was reportedly provided to contractors in May 2005, the public and other interested parties – including land-use decision-makers concerned with water supply reliability – were not provided with a draft until mid-November 2005.) Clearly, the information from this report has not been readily available for use in the preparation of the 2005 UWMPs. To the extent that assertions of the SWP reliability may be in question, all of the UWMPs relying on SWP supplies for any portion of their water will be flawed. It is most unfortunate that DWR did not release the draft report much earlier (e.g. at least in May when it was provided to contractors) in order for the accuracy and validity of the report to be discussed.

This relates to the second problem, which is that the report is supposed to be provided every two years. The two-year cycle is not being met.

**Conclusion**

The 2002 reliability report acknowledged for the first time that the SWP cannot deliver full "Table A" volumes. This was an important step towards a more honest and accurate assessment of system reliability. It too, however, was strongly criticized for its over-reliance on the Calsim II model. The current draft report begins its defense of Calsim II in the *Forward* and continues it at tedious length throughout the document. Rather than mounting a protracted defense of an imperfect model, the SWP should be subjected to a credible reliability analysis with outside peer review. DWR staff should be directed to develop an open process that begins to account for the range of factors that will likely impact system reliability.

Sincerely,

Robert C. Wilkinson

3

STATE OF CALIFORNIA – THE RESOURCES AGENCY
ARNOLD SCHWARZENEGGER, Governor
DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

March 24, 2006

Robert C. Wilkinson, Ph.D.
1428 West Valerio
Santa Barbara, California 93101

Dear Dr. Wilkinson:

This is in response to your letter of December 23, 2005 commenting on the draft State Water Project Delivery Reliability Report–2005 (Report 2005).

In your letter, you state that the Report 2005 does not provide an accurate assessment of the delivery ability of the State Water Project (SWP) because it does not incorporate future uncertainties associated with such things as climate change, earthquakes, terrorism, etc. You also point out that the timing of Report 2005 is problematic because it was not released early enough to be publicly reviewed prior to being incorporated into Urban Water Management Plans and does not meet the two-year interval required for updating this information.

The estimates contained in the Report 2005 are the best quantifications available of the delivery ability of the SWP. These estimates are limited, however, because of the uncertainty of future conditions. The Department of Water Resources (DWR) will continue to use the CalSim model as appropriate for analyses but other information is being developed that will help us analyze, understand, and prepare for our uncertain future. Per the Governor's directive (Executive Order S-3-05), the potential impacts of climate change on the State's resources, including water supply, are being evaluated. Preliminary estimates have been done, using CalSim-II, of the potential impact upon the SWP in 50 to 100 years if no additional conveyance facilities or upstream reservoirs are built. As these estimates become more refined, they will be helpful in guiding strategies for the management and development of the State's water resources, including improvements to the SWP.

In addition, DWR is working on two projects that will improve our ability to make qualitative or quantitative statements about the reliability of conveyance across the Sacramento-San Joaquin Delta. They are: the Delta Risk Management Strategy, which will assess risks to the Delta from floods, seepage, subsidence, and earthquakes, evaluate the consequences of levee failure, and develop recommendations to manage the risk; and a broader public process to develop a shared vision of a sustainable Delta that continues to support societal needs related to land use, recreation, water supply, transportation, energy, and environmental health. The Delta Vision process incorporates the requirements of AB 1200 passed by the legislature and signed by the Governor in 2005. Although none of these efforts will be completed before release of the next Reliability Report, some preliminary results and conclusions may be completed in time for inclusion. Subsequent Reliability Reports will fully incorporate this information.







DWR does not want to leave any reader of the Report 2005 with the impression that this developing information is being ignored. Therefore, the final report includes a discussion of these uncertainties, the efforts to quantify them, and a commitment to incorporate the above-mentioned information as it is developed and refined.

You make the point that the report is supposed to be updated every two years and this condition has not been met. In addition, you state that the report should be available to the public as a draft and finalized prior to deadlines for local agency Urban Water Management Plans. I agree that the report should be available to the public as a draft and finalized prior to deadlines for local agency UWMPs. It is unfortunate that the review and completion of the Report 2005 could not be done in early 2005 for incorporation into UWMPs and well within the two-year interval specified in the settlement agreement (*Planning and Conservation League v. Department of Water Resources* (2000) 83 Cal. App. 4th 892). The objectives of DWR for the Reliability Report are to encourage public discussion and understanding of the estimation of the SWP delivery capability, meet the conditions of the settlement agreement, and provide the best available quantification of SWP deliveries. Given the situation this year, DWR chose to provide the information to the SWP water contractors as a memorandum in May, 2005 and to delay the completion of the final Report 2005 to allow public review of a draft. Public review of the draft is not a requirement of the settlement agreement but the review encourages public discussion of the issue and improves the final report.

The final Report 2005 will be issued soon and will include an appendix containing the comment letters on the draft report and DWR's responses. Thank you for your comments and recommendations. If you wish to discuss this further, please contact Gerald Johns, DWR's Deputy Director at (916) 653-8045 or jjohns@water.ca.gov.

Sincerely,

***Original signed by***

Lester A. Snow
Director

cc: P. Joseph Grindstaff, Acting Director
California Bay-Delta Authority
650 Capitol Mall, Fifth Floor
Sacramento, California 95814

# Attachment 2

MEMORANDUM OF UNDERSTANDING
BETWEEN
THE DEPARTMENT OF WATER RESOURCES OF THE
STATE OF CALIFORNIA
AND
KERN COUNTY WATER AGENCY
FOR
DEVELOPING AND OPERATING THE KERN WATER BANK

THIS MEMORANDUM OF UNDERSTANDING (MOU), made this 25th day of March, 1987, sets forth the principles for developing, operating, and managing the proposed Kern Water Bank, located within Kern County, as an additional conservation facility of the State Water Project (SWP). The Department of Water Resources (Department) executes this Agreement for and on behalf of the State Water Project. The Kern County Water Agency (Agency) executes this Agreement for and on behalf of its Member Units, local water districts, and all other parties within the Agency having a physical or economic interest in the Kern Water Bank. It is the intent of the parties that this MOU serve as the statement of principles on which the negotiation of a comprehensive contract between the Department and the Agency will be based, and will, among other things, be consistent with the SWP water service contracts, provide for definition of Elements of the Kern Water Bank, define program management and operation responsibilities, and provide for supplemental land use.

The Department and Agency hereby agree to the following principles:

1. Kern Water Bank: Definition and Purpose. All opportunities by the Department to store imported surface water in the Kern Ground Water Basin by contract with the Agency are collectively referred to as the "Kern Water

Bank". The primary purpose of the Kern Water Bank is to augment the dependable water supply of the State Water Project. Incidental to its primary purpose, the Kern Water Bank will produce local benefits in the form of conservation of local water supplies, ground water overdraft correction and improved ground water levels.

2. Contract. This memorandum of understanding shall constitute agreement between the Department and the Agency under Section 11258 of the Water Code for the Department to proceed with the purchase of land for the project, but a further contract shall be required for compliance with Section 11258 before construction and operation of the Kern Water Bank project can proceed. The Contract shall be consistent with the principles contained in this MOU.

It is recognized that there may be a number of phases or "Elements" to the Kern Water Bank. The Contract will provide that each Element to the Kern Water Bank be subject to Agency approval, consistent with Section 11258 of the California Water Code. The Department will consult with the Agency as to all substantive matters relating to the planning, construction and operation of Elements of the Kern Water Bank.

3. Consultation. The Department will consult with its State Water Project contractors and the Agency will consult with its Ground Water Storage Advisory Committee (GWSAC) as to the terms and conditions of this MOU, the Contract and all other substantive matters relating to the planning, construction and operation of Elements of the Kern Water Bank.

4. Kern Water Bank - General Provisions. The following provisions shall be applicable to all Elements of the Kern Water Bank:

(a) Kern Water Bank Elements. The Contract shall include provisions covering how the Department and the Agency will work with local districts in the development of Elements to the Kern Water Bank. Elements

shall be included only if agreement is reached as provided in paragraph 2 above, and the Department makes the determination that such Elements are engineeringly feasible, capable of producing water for the SWP, and economically competitive with alternative new SWP water supply sources. Elements to be considered shall include but not be limited to direct ground water recharge and in-lieu programs.

(b) Develop Plans. Prior to inclusion of an Element to the Contract, the Department shall prepare a plan of development. Criteria for development plans shall be included in the Contract.

(c) Management Responsibilities. The Department shall have overall management responsibilities for the Kern Water Bank. All decisions pertaining to the scheduling of water operations are considered management responsibilities.

(d) Responsibilities for Operations. The Department will contract with the Agency, and subject to Department approval, the Agency with local districts, for the physical operation and maintenance of Kern Water Bank facilities, including transportation of SWP water for storage and extraction and maintenance of canals, recharge basins, and extraction wells associated with Elements of the Kern Water Bank. The contract will provide for periodic reevaluation of the arrangements for operating and maintaining the facilities and shall allow for possible adjustments in the contract.

(e) Operational Criteria.

(1) The operation of the Kern Water Bank as an additional SWP conservation facility shall be integrated with overall SWP operations under the Rule Curve in effect at the time.

(2) No deliveries to storage in the Kern Water Bank shall be made if such deliveries would otherwise cause an increase in entitlement deficiencies to long-term SWP water supply contractors in the year of storage.

(3) The Contract will provide that Elements of the Kern Water Bank will minimize any interference with local ground water uses. Improved ground water conditions that result from the State Water Project Kern Water Bank program will be considered when evaluating any interference with local ground water uses.

(4) The Department and the Agency shall develop monitoring programs to evaluate the specific and cumulative effects of each Element's operation on local ground water operations. Significant adverse impacts on local ground water operations shall be mitigated by the Department. The Department and the Agency shall also develop technical models to predict potential such impacts of Kern Water Bank activities on local ground water operations.

(5) Significant adverse environmental impacts shall be mitigated to the extent required by law.

(6) The Contract shall specify the manner in which the maximum amounts to be extracted and the maximum rates of extraction from Elements of the Kern Water Bank in any one year shall be determined. Water may be extracted from the Kern Water Bank only to the extent that it was stored previously.

(7) The Department and the Agency shall agree on assumptions for water losses associated with Kern Water Bank activities. After allowances for losses and mitigation all remaining stored water shall be available for SWP extraction and use.

(8) The Contract shall specify for each element the amount of storage that will be available for SWP purposes in the Kern Water Bank.

(f) Local Uses. In consideration for SWP use of the local ground water storage capacity, the Contract will provide for local uses of land and improvements acquired or constructed for each Element of the Kern Water Bank. Such local uses shall be defined and compensation therefore, if required, shall be provided for in the Contract.

5. Kern Fan Element. The Department, assisted by the Agency, is conducting appraisals and studies to determine the desirability of acquiring up to 46,000 acres of property located on the Kern River Fan west of Bakersfield. Acquisition of the property and construction of related recharge, extraction and conveyance facilities is hereinafter defined as the "Kern Fan Element" of the Kern Water Bank. In addition to the other provisions contained in this MOU, the Contract shall include, but not necessarily be limited to, the following specific provisions associated with the Kern Fan Element:

(a) Agency Option of Purchase. The Agency shall have the option to acquire all or any portion of the land associated with the development of the Kern Fan Element, consistent with provisions of the Contract. If the Agency does not exercise this option in accordance with provisions of the Contract within 90 days of a decision by the Department to proceed with land purchase, the Department shall purchase the land as part of the State Water Resources Development System. For a period of ten years after the date of acquisition by the Department, the Agency shall have the right to purchase the land from the Department, under terms specified in the Contract, provided that the Department's right to use the area for project purposes will be preserved. Consistent with Section 11464 of the Water Code the Department shall not sell facilities constructed or acquired for the Kern Water Bank.

(b) Land Uses. The Contract will provide for a consultation process among the Agency, DWR and appropriate local agencies in determining nonwater related uses of the property acquired for the Kern Fan Element.

(c) Management and Operations and Maintenance. The Department will manage and the Agency will operate and maintain the Kern Fan Element property and facilities, including canals, recharge basins and extraction wells associated with direct recharge and extraction activities. The Agency's operation shall include transportation of imported water from the California

Aqueduct to storage facilities and from extraction facilities to the Aqueduct (Section 4(d)).

(d) Overdraft Correction. Farming operations associated with the property to be acquired for the Kern Fan Element shall be taken out of production over a five (5) year period from the date of purchase of the property. Water associated with the reduction of ground water overdraft as a result of said idling of land shall remain as a benefit to the local ground water basin, and shall not be exported, either directly or indirectly, from the basin. It is understood and agreed, however, that the reduction of overdraft shall be defined and agreed to in the Contract, and the resultant improvement in ground water levels will be considered when evaluating the adverse effects of project extractions on local ground water uses.

(e) Local Water Related Uses. The Contract will provide for local uses of the land acquired for the Kern Fan Element, and will provide that facilities constructed for use by the SWP be available for recharge and extraction of local water by the Agency. Such local uses shall be defined and compensation therefore, if required, shall be provided for in the Contract.

6. Legal and Policy Considerations.

(a) The Department and the Agency in consultation with the other SWP contractors and affected local districts will identify and resolve to the satisfaction of the Department any legal issues related to storage and extraction of SWP water prior to execution of the Contract.

(b) The Department will initiate no legal actions or other activities to adjudicate the Kern Ground Water Basin as a result of its interest in the Kern Water Bank. This will not restrict the right of the Department to take action other than basin adjudication to recover SWP water stored in the Kern Water Bank as provided in the Contract between the Department and Agency. The Contract will provide for remedial actions in the

event that the Department is prevented from recovering water, as provided in the Contract.

IN WITNESS WHEREOF, the parties hereto have executed this Memorandum of Understanding.

APPROVED AS TO LEGAL FORM
AND SUFFICIENCY:

By _____
Chief Counsel

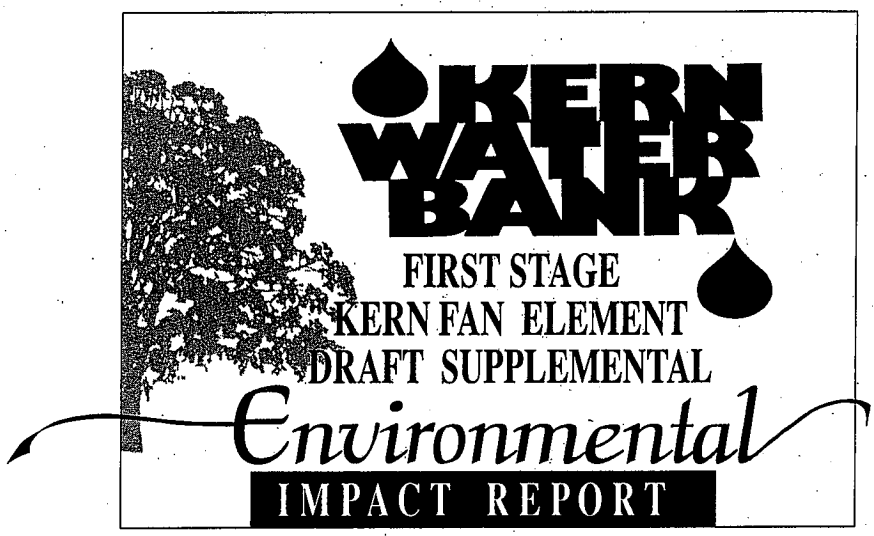
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES

By _____
Director

KERN COUNTY WATER AGENCY

By _____
Title President, Board of Directors

# Attachment 3




December 1990

# FOREWORD

The Kern Water Bank, defined as all opportunities to store and extract State Water Project water in the Kern County ground water basin, will add operational flexibility and augment water supplies for the SWP. The Kern Water Bank will be operated for the SWP by the Kern County Water Agency, the SWP water contractor in the region.

The proposed First Stage of the Kern Fan Element is the initial component of the Kern Water Bank program. It is designed to increase SWP water supplies by more than 50,000 acre-feet annually at a competitive cost and open up even greater opportunities for ground water banking in Kern County.

Only a small amount of the 20,000 acres of land purchased for the Kern Fan Element will be used for long-term recharge. While a substantial portion of the remaining acreage could be used for intermittent recharge of local flood flows, this land and other acreage on the property will provide significant potential for restoring native habitat suitable for threatened and endangered wildlife species. Specific wildlife habitat measures are expected to be developed in the areas of the permanent recharge ponds as well. Over the next few years, an advisory process for comprehensive land use will unfold, and will be used to guide the conversion of much of this land from its present farming use to the potential uses set forth in this report.

The conversion of farmed land to the recharge and extraction program will save water, since irrigation on the property now contributes directly to ground water overdraft. Project benefits include this overdraft reduction, as well as reduced regional ground water pumping costs due to elevated water levels resulting from maintenance of an SWP storage account in the basin. Water would be pumped out only in dry years when SWP surface reservoirs could not fully meet SWP water delivery demands.

Studies are now under way to add more elements to the Kern Water Bank, in cooperation with the Kern County Water Agency and local water districts. Each of these programs will be addressed in separate environmental impact reports, as needed. The Department of Water Resources will continue to pursue ground water banking as one of the promising water management tools for meeting California's water needs.

David N. Kennedy, Director
Department of Water Resources

State of California
**GEORGE DEUKMEJIAN,** Governor

The Resources Agency
**GORDON K. VAN VLECK,** Secretary for Resources

Department of Water Resources
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# CONTENTS


Foreword ..... iii
Organization, Department of Water Resources ..... v
Executive Summary ..... xiii

**1. INTRODUCTION** ..... 1
- Purpose of Kern Fan Element ..... 1
- Purpose of Supplement to the Program EIR ..... 2
- Proposed Action ..... 2

**2. PROJECT DESCRIPTION** ..... 5
- General Description ..... 5
- Recharge Facilities ..... 5
  - Recharge Ponds ..... 7
  - Recharge Conveyance Facilities ..... 13
- Extraction Facilities ..... 15
  - Wells ..... 15
  - Extraction Conveyance Facilities ..... 17
  - Buena Vista Lakes Pumpback Facilities ..... 18
- Other Project Facilities ..... 18
  - Climatic Monitoring Station ..... 18
- Advance Entitlement Delivery ..... 20
- Kern Fan Element Operations ..... 21
  - Recharge Operations ..... 21
  - Extraction Operations ..... 23
- Operating Criteria ..... 24
  - Recharge Operating Criteria ..... 24
  - Extraction Operating Criteria ..... 24

**3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES** ..... 25
- Water Supply Studies ..... 25
  - Impacts on SWP Delivery Capability ..... 29
  - Decreases In Project Deficiencies ..... 30
  - Kern Fan Element Storage Fluctuations ..... 32
  - State Water Project Operational Flexibility ..... 32
    - Use of Excess Delta Flows ..... 37
    - Impact on Oroville Reservoir ..... 37
- Potential Impacts of Diversions From the Sacramento–San Joaquin Delta ..... 38
  - State Water Project Planning ..... 38
  - Impacts On Delta Outflow ..... 38
  - Winter–Run Salmon Impacts ..... 39
  - 1986 Delta Pumping Plant Agreement ..... 41
- Water Quality ..... 42

Recharge Water Quality ..... 42
Salt Balance ..... 43
Ground Water Quality ..... 44
Known Water Quality Problems ..... 46
Ethylene Dibromide ..... 46
Toxaphene ..... 49
Eptam (EPTC) ..... 49
Diuron ..... 49
Petroleum Hydrocarbon ..... 49
Arsenic ..... 52
Gross Alpha/Uranium ..... 52
Excessive Total Dissolved Solids ..... 52
Implications of Water Quality Problems ..... 56
Pesticides ..... 56
Petroleum Production ..... 57
Recharge and Extraction Concerns ..... 61
Recharge Water Level Concerns ..... 61
Recharge Water Quality Concerns ..... 61
Extraction Water Level Concerns ..... 62
Extraction Water Quality Concerns ..... 69
Vegetation ..... 69
Valley Saltbush Scrub (Ss) ..... 69
Non-native Grassland (G) ..... 71
Valley Sacaton Grassland (GV) ..... 71
Mulefat Scrub (Sm) ..... 71
Great Valley Mesquite Savanna (Sp) ..... 71
Southern Cottonwood Willow Riparian (Rs) ..... 71
Canal (C) ..... 71
Pond (P) ..... 71
Disturbed (D) ..... 72
Agriculture (K) ..... 72
Fallow Field (F) ..... 72
Wildlife ..... 72
Reptiles and Amphibians ..... 72
Birds ..... 74
Mammals ..... 74
Impacts of Construction and Operation Activities on Sensitive Wildlife ..... 78
Land Use ..... 79
Potential Near Term and Future Land Uses ..... 79
Ground Water Recharge and Conveyance Facilities ..... 79
Agricultural Leases ..... 80
Wildlife, Native Vegetation and Recreation ..... 80
Mineral Extraction ..... 82
Land Use Advisory Committee ..... 83

SWP Economic Benefits ..... 121
South Coast Region Benefits ..... 121
Agricultural Benefits for SWP Service Areas in the Tulare Lake Region ..... 123
Benefits in Other SWP M&I Service Areas ..... 123
Summary of Annual Benefits ..... 124
Local Project Area Economic Benefits ..... 125

**7. SIGNIFICANT IRREVERSIBLE ENVIRONMENTAL CHANGES ..... 127**

**8. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY ..... 129**

**BIBLIOGRAPHY ..... 131**

**CONSULTATION AND COORDINATION ..... 133**

**GLOSSARY ..... 135**

**ABBREVIATIONS AND ACRONYMS ..... 139**

## APPENDICES

A Kern Water Bank Land Use Advisory Subcommittee Recommendations for the Kern Fan Element ..... 143
B Status of Potential Sensitive Plant Species for Kern Fan Element ..... 153
C Wildlife Species List ..... 155
D Measuring Economic Benefits of the Kern Fan Element ..... 157

## FIGURES

1 1987 Conceptual Layout, Kern Fan Element Facilities ..... 3
2 Proposed First Stage Facilities ..... 6
3 First Stage Recharge System ..... 8
4 Conceptual Cross-Section, Typical Recharge Basin ..... 10
5 Tumbleweed Farm Ponds Conceptual Plan ..... 11
6 First Stage Extraction System ..... 16
7 Possible Sites for Regional Climate Monitoring Stations ..... 19
8 Water Supply Improvements, With and Without Surcharge ..... 31
9 Frequency of SWP Annual Deliveries, 3.5 MAF Demand ..... 33
10 Frequency of SWP Annual Deliveries, 3.7/4.2 MAF Demand ..... 34
11 End-of-Month Storage in the KFE, 3.5 MAF Demand ..... 35
12 End-of-Month Storage in the KFE, 3.7/4.2 MAF Demand ..... 36
13 Location of Wells Sampled for Water Quality ..... 45
14 Generalized Area With Detectable EDB ..... 48
15 Borehole Locations at the Chevron Pipeline ..... 50
16 Top of Crude Oil Contour Map – Chevron Pipeline ..... 51

17 Areas of Contaminated Soil Along Chevron Pipeline Corridor ..... 53
18 Generalized Areas of Arsenic Exceeding the MCL ..... 54
19 Generalized Areas With TDS Greater Than 500 mg/L ..... 55
20 Location of Pesticide Storage and Mixing Sites ..... 58
21 Location of Known Petroleum Transport Pipelines ..... 59
22 Elements 221, 219, 250, and 224: Projected Ground Water Levels, Unconfined Aquifer ..... 63
23 Unconfined Water Level Impacts (1975) ..... 66
24 Unconfined Water Level Impacts (1935) ..... 67
25 Vegetation Map ..... 70
26 Wildlife Map ..... 73
27 Walking Transect Survey ..... 77
28 Conceptual Reserved Areas - Second Stage ..... 81
29 Location of Water Level Monitoring Wells ..... 88
30 Proposed Regional Monitoring Well Network ..... 89
31 Proposed 200-Foot Water Quality Monitoring Wells ..... 93
32 Areas of Elevated TDS Near Tupman ..... 95
33 Areas of Proposed Local Recharge ..... 105
34 Metropolitan Bakersfield Habitat Conservation Plan ..... 107
35 Map of Petroleum Reserve No. 1 and ARCO Seismic Survey ..... 109
36 Economic Risk Model Flow Chart ..... 118
37 South Coastal Service Area Option Displaced by KWB Yield ..... 122

## TABLES

1 Recharge Pond Characteristics ..... 9
2 First Stage Kern Fan Element Water Supply Study Results ..... 29
3 Pesticides with a Significant Probability of Reaching Ground Water ..... 57
4 Projected Total Kern Fan Element Pumping Cost Savings ..... 68
5 Kern Fan Element Track Pad Results ..... 76
6 Kit Fox Activity ..... 76
7 Kit Fox Den Locations ..... 76
8 Land Use Acres – First Stage ..... 80
9 Significant Effects and Mitigation Measures ..... 86
10 Characteristics of Existing Monitoring Wells ..... 90
11 Standard Minerals, Minor Elements, and Physical Parameters Analyzed in the First Stage Monitoring Program ..... 97
12 Chlorinated Organic Pesticides ..... 98
13 Organic Phosphorus Pesticides ..... 98
14 Carbamate Pesticides ..... 98
15 Rank One and Rank Two Pesticides With a History of Use on KFE Property ..... 99
16 Purgeable Organics ..... 99
17 M&I Shortage Contingency Options in the South Coast Region ..... 113
18 Local Long-Term Options – South Coast Region ..... 114

19 Willingness to Pay ..... 117
20 Local Service Area Alternatives, Local Long-Term Optiion Use —
South Coast Region ..... 120
21 Analysis of the First Stage Kern Fan Element, South Coast Region ..... 122
22 Annual Agricultural Benefits ..... 124
23 Summary of Annual Benefits ..... 124

# EXECUTIVE SUMMARY

The Department of Water Resources (DWR) proposes to construct and operate the First Stage of the Kern Fan Element (KFE) of the Kern Water Bank (KWB). The KWB was initially described in the Program Environmental Impact Report, entitled *Artificial Recharge, Storage and Overdraft Correction Program, Kern County, California* (Kern Water Bank), in December 1986. The purposes of the KFE are to increase the firm water supply of the SWP, to reduce overdraft in the Kern County Ground Water Basin, and to provide recharge opportunities for local users. In addition, opportunities for other land uses, such as restoring native habitat, creating wetland habitat, and providing opportunities for recreation are also envisioned. DWR is currently evaluating a staged development of the KFE. The First Stage will be a scaled-down operation of the ultimate one million acre-foot storage project described in the April 1987 *Kern River Fan Element, Kern Water Bank, Preliminary Technical Report* (Technical Report).

This draft Supplemental EIR covers the impacts of constructing and operating the First Stage of the Kern Fan Element and is intended to augment the 1986 Program EIR. The Draft SEIR incorporates the Program EIR by reference. The SEIR provides an opportunity for public review of the potentially significant effects of the proposed project. Additional comments received following the review of this document will be incorporated into the final SEIR.

Following release of the Program EIR, DWR began reconnaissance-level studies for the KFE portion of the KWB. The Technical Report described a ground water storage project with a maximum storage of one million acre feet. The report also described base conditions for ground water geology, soils, water quality, and water supply for the KWB property. Water would be conveyed from the California Aqueduct to the proposed recharge basins on the KFE property and to existing recharge basins within the City of Bakersfield's 2,800-Acre Recharge Area.

The First Stage is intended to evaluate the actual recharge rates for various soil types, identify potential operation problems, and optimize future operation. The principal components of the First Stage will be the construction of recharge basins, service canals and pipelines, and modifications and/or construction of new wells on the KFE property. The ultimate design and operation of the KFE program will be based on experience gained during the First Stage operation.

## PROJECT DESCRIPTION

The KFE property consists of 20,000 acres located southwest of Bakersfield, in Kern County. The First Stage recharge facilities will require 1,100 acres of ponds, as well as use of the adjacent City of Bakersfield's 2,800-Acre Recharge Area. The First Stage program has been planned for a maximum ground water storage capacity of 350,000 acre-feet. Recharge facilities will provide a maxi-

mum recharge capacity of 90,000 acre-feet from November through April. Extraction facilities will provide the capacity to extract 75,000 acre-feet annually. Alternatives to the proposed project will be limited to relocating ponds and extraction wells within the existing KFE boundary.

## RECHARGE AND EXTRACTION FACILITIES

The City of Bakersfield's recharge facilities and the six recharge basins on the KFE property will be used for the First Stage program. To the extent possible, existing facilities will be used. Ponds sites on the KFE property were selected to avoid known water quality problems or potential water quality threats until more is known about the area. A second criterion was to locate First Stage facilities a minimum of 500 feet away from oil pipelines to avoid recharging over potentially contaminated soils and to restrict mounding in pipeline areas. Five of the six recharge basins will be served by the Cross Valley Canal through new turnouts. The sixth will be served by an existing CVC turnout and the City's 2,800-Acre Recharge Area. The agreement with the City of Bakersfield for use of the 2,800-Acre Recharge Area requires that a minimum of 10 percent of the total recharge take place within their Recharge Area.

Extraction facilities will involve the use of 27 wells; 25 existing and two new wells. Use of the 27 wells with conservative long-term pumping capacity assumptions will result in an extraction capability of about 75,000 acre-feet per year. During extraction years, water will be pumped from these wells at a uniform rate and delivered to Kern County Water Agency, in exchange for a like amount of SWP entitlement that would otherwise be delivered from the California Aqueduct during that year. Ground water withdrawals and subsequent delivery would count as the fulfilled "advanced entitlement delivery", allowing a reduction in entitlement deliveries from the Aqueduct.

### Water Supply Studies and Accomplishments

Computer simulation studies were conducted to evaluate the potential water supply accomplishments at three future levels of SWP annual delivery requests: 3.5 million acre-feet, 3.7 million acre-feet, and 4.2 million acre-feet. The first two studies assumed existing SWP facilities and operational constraints. The last study assumed that facilities and programs would be in place to allow full use of the four new pumps at the Banks Delta Pumping Plant. This would allow greater Delta exports to occur, and provide greater opportunities to recharge water during winter months.

All of the studies used a generalized version of the current "Risk Curve", a technical analysis to determine how much to deliver in the current year and how much to save in storage for delivery in future years. This concept, greatly refined in the past two years, has been the foundation of SWP operations in recent years.

The study results are shown on the following page.

**FIRST STAGE KERN FAN ELEMENT WATER SUPPLY STUDY RESULTS**
**In 1,000s of acre-feet**

| | Level of SWP Demand, In MAF | | |
|---|---|---|---|
| | 3.5 | 3.7 | 4.2 |
| Average Annual Dry Period Supply (AADPS) | 52 | 54 | 70 |
| 57-Year Average | 31 | 44 | 56 |
| Average Delivery Increase in Years That Improvement Is Possible | 59 | 68 | 72 |
| 57-Year Average | 33 | 49 | 68 |
| Average Delivery Increase in Years That Improvement Is Possible | 64 | 73 | 84 |

The water supply accomplishments increase as demands increase. One reason is that the ground water storage account is operated more aggressively over time to meet the increased water delivery demands. In most years, increased deliveries can be made. A second reason is that additional pumping capability in the Delta at the 4.2 million acre–foot level of demand study allows for greater opportunities to recharge water, and allows the Kern Fan Element to operate more effectively as an integrated part of the SWP. This additional effectiveness is reflected in the additional water supply accomplishments, as well as additional operational flexibility in SWP reservoirs.

Operation of the Kern Fan Element will result in greater exports of water from the Delta. This will be through the combined action of diverting water during winter months for recharge, and delivering additional water to SWP water contractors as a result of accounting for KFE storage in the Risk Curve. The average increases in Delta exports are roughly equivalent to the average increases in water supply accomplishments for each of the three levels of study. The six–month period for recharge coincides with the period of winter runoff and the availability of higher Delta outflows, as well as being outside of the period of export limits for fishery protection.

## Project Benefits

The proposed project will have the following beneficial effects:

- The interior of the recharge ponds will be managed to optimize recharge rates, minimize the area needed for recharge ponds, and minimize conflicts with wildlife. The surrounding vegetation would be managed for wildlife benefits.
- The vegetated areas immediately surrounding the ponds could be provided with water supplies from both the recharge and extraction systems and managed primarily for wildlife benefits.
- Naturally occurring topographical features within the ponds will be developed to the extent practicable into vegetated islands that would be maintained as nesting habitat for waterfowl and other birds. The nesting islands could be provided in a selected cell for each of the pond groups.
- During SWP recharge years and locally wet years, the First Stage recharge ponds and their nesting islands would provide additional wildlife benefits at a small cost for the additional water supply required in April through June.
- Wildlife watering devices will be connected to each of the extraction wells to provide a source of water during extraction years to complement the water supply available to wildlife during recharge years from open canals, ponds, and adjacent wetland/riparian habitat.

- Some lands not actively used or reserved for recharge basins can be developed as preserves for sensitive species, such as the San Joaquin kit fox, Tipton's kangaroo rat, and the blunt–nosed leopard lizard.

# EFFECTS OF THE PROPOSED ACTION AND MITIGATION

## Water Quality

A number of pesticides have been used that have a potential to contaminate ground water throughout that portion of the KFE property that was previously farmed. Other potential contaminants are associated with oil field activities. First Stage facilities have been designed and located to avoid areas with degraded water quality. In some cases, this resulted in locating First Stage facilities away from prime recharge areas, pending a determination of the extent of contamination, if any, in these areas. In areas of potential ground water contamination, recharge and extraction patterns will be carefully monitored to minimize movement of contaminated water to extraction wells. Extraction wells will be located away from areas with known contamination. Recharge facilities will not be located in areas with known soil contamination and will be operated in a manner that will not bring either recharge water or ground water into contact with areas of soil contamination.

An exploration and sampling program is being conducted at each recharge site to determine whether contaminants are present. To the extent that pesticides are present, solutions are expected to include on–site and/or nearby use of water from the affected well(s) for irrigation to the extent that water quality is suitable for that purpose, until the problem no longer exists. Additionally, there is sufficient flexibility in the number and capacity of first Stage extraction wells to shift pumping away from a problem area.

Petroleum hydrocarbon contamination from pipelines represents the most significant ground water quality threat on the KFE property. Contaminated areas on the property could limit use of some portions of the property for recharge. In order to minimize potential threats from pipeline leaks, all First Stage recharge basins will be set back 500 feet from identified pipelines.

## Ground Water Level Concerns

Water levels are expected to rise on a regional basis during recharge operations. Local mounding is expected in the immediate area of the basins, however, no off–site problems are anticipated. To the extent that potential interference problems do occur, such potential problems will be handled by shifting KFE recharge to other areas and/or reducing recharge.

## Extraction Water Level Concerns

Ground water levels will be monitored to prevent unacceptable water level impacts to surrounding users. If unacceptable impacts are apparent, pumping will be shifted away from potential problem areas or the affected parties will be compensated for direct impacts associated with the KFE operation.

## Vegetation

No significant impacts to native vegetation are anticipated since no construction or operation activities are contemplated within areas of native vegetation.

## Delta Impacts

The potential exists for winter–run salmon and other races of salmon to be impacted by additional Delta diversions required for the KFE. The potential adverse impact is not possible to quantify at this time. The KFE will result in diversions that will add only 1.5 percent to the total diversion. By itself, this would not be significant, however, due to existing concerns in the Delta, the winter–run is now considered endangered and any impact could potentially be significant.

An interagency winter–run team has been established to develop a recovery plan for the winter–run salmon in the upper Sacramento River. A joint federal/State recovery team has also been established pursuant to the endangered species acts. In addition, DWR is proceeding with informal consultation with the National Marine Fishery Service and DFG on the potential impacts of proposed Delta facilities and south of the Delta storage projects on winter–run salmon. If the recovery team and consultation process conclude that SWP pumping causes a take, DWR will work to provide the appropriate mitigation and/or measures to minimize the adverse effects. If an incidental take permit is required and appropriate, DWR will work with the respective regulatory agency in compliance with the State or federal Endangered Species Act.

## Wildlife

Construction activities may cause potentially significant effects to the blunt–nosed leopard lizard, Tipton's kangaroo rat, and the San Joaquin kit fox, all threatened or endangered species.

Before construction begins, a qualified biologist will be retained to survey the area and determine site–specific conditions that should be avoided. Potential kit fox dens will be excavated or avoided. Buffer areas will be required around potential and natal dens. Speed limits will be posted during the breeding season to restrict vehicle traffic.

DWR will initiate formal consultation with DFG and the U.S. Fish and Wildlife Service, pursuant to the endangered species acts. DWR will prepare a conservation plan so future activities at KFE do not result in a take of endangered species.

## Local Recharge

Kern County Water Agency wants to develop 4,000 acres of the KFE property for local recharge and extraction of Kern River floodwaters. To the extent KCWA makes use of the KFE recharge facilities, no additional wildlife disruption is anticipated beyond what is discussed in the SEIR. However KCWA envisions spreading flood flows over large areas of land outside the confined KFE recharge basins. No site–specific work has been conducted for proposed local recharge areas in sufficient detail to include in this Draft SEIR. Before KCWA could implement such a local recharge program, an environmental analysis of the effects of the proposed local facilities, particularly on surrounding water levels and sensitive wildlife species would need to be completed and adequate mitigation measures would need to be identified and/or implemented.

# Chapter 1. INTRODUCTION

The Final Program Environmental Impact Report (Program EIR), entitled *Artificial Recharge, Storage and Overdraft Correction Program, Kern County, California (Kern Water Bank)* was issued in December 1986. The proposed action described a conceptual "element," the Kern Fan Element (KFE) of the Kern Water Bank (KWB), which involved analyzing the potentially significant environmental effects of acquiring up to 46,000 acres of land in Kern County to develop a ground water storage program with the purpose of increasing State Water Project (SWP) water supply. The 1986 EIR reviewed a number of alternative KFE options and recommended a program that ultimately resulted in purchasing about 20,000 acres.

When the 1986 EIR was released, the Department of Water Resources (DWR) announced that full feasibility studies would be conducted in part to refine the design and operation of the proposed project. These activities were conducted to determine whether additional significant effects would occur that were not addressed in the earlier EIR. If additional environmental consequences could potentially occur, DWR would issue a supplemental EIR addressing the impacts. However, if future activities within the KWB (either the KFE or other elements) resulted in no new significant effects, then subsequent activities could be approved as being within the scope of the Program EIR (1986).

The feasibility studies conducted to date for the KFE indicate that there are additional effects that were not specifically addressed in the Program EIR. The construction and operation of recharge facilities for the KFE will result potentially in a take of endangered species known to inhabit the KFE property. Therefore, DWR prepared this Draft Supplemental EIR to evaluate the potentially significant environmental impacts associated with the construction and operation of the KFE.

DWR is currently pursuing a staged development of the KFE. The initial or "First Stage" will be a scaled-down operation of the ultimate one-million-acre–foot storage project, described in the April 1987 *Kern River Fan Element, Kern Water Bank, Preliminary Technical Report* (Technical Report). Subsequent development will increase the operation of the KFE to the ultimate size. Future long-term KWB activities also will include consideration of other "local elements." Separate environmental and feasibility studies for these proposed elements will be conducted, if required.

## PURPOSE OF THE KERN FAN ELEMENT

The purposes of the KFE are to increase the firm water supply of the SWP, to reduce overdraft in the Kern County Ground Water Basin, and to provide recharge opportunities for local users. Opportunities for other land uses, such as restoring native habitat, especially for threatened and endangered species, creating wetland habitat, and providing local recreational opportunities, will also be pursued.

## PURPOSE OF SUPPLEMENT TO THE PROGRAM EIR

This draft Supplemental EIR (SEIR), which is one stage of the Kern Water Bank program, is intended to augment the 1986 Program EIR by focusing on significant issues associated with the proposed specific ground water recharge and extraction project. The SEIR provides an opportunity for public review of additional potentially significant changes to the proposed KFE. This SEIR incorporates the Program EIR by reference. Before approving the proposed project, DWR will identify the significant effects associated with the proposed action, make appropriate findings for any significant impacts that are unavoidable, and specify how impacts will be either mitigated or minimized.

The Technical Report set forth the results of the reconnaissance-level studies for the KFE portion of the KWB. The Technical Report described base conditions of ground water geology, soils, water quality, and water supply for the property. The report set forth a specific proposed plan, and provided results of computer simulation studies for both SWP water supply augmentation and projected ground water basin impacts. The report also summarized the local element proposals as they existed at the time.

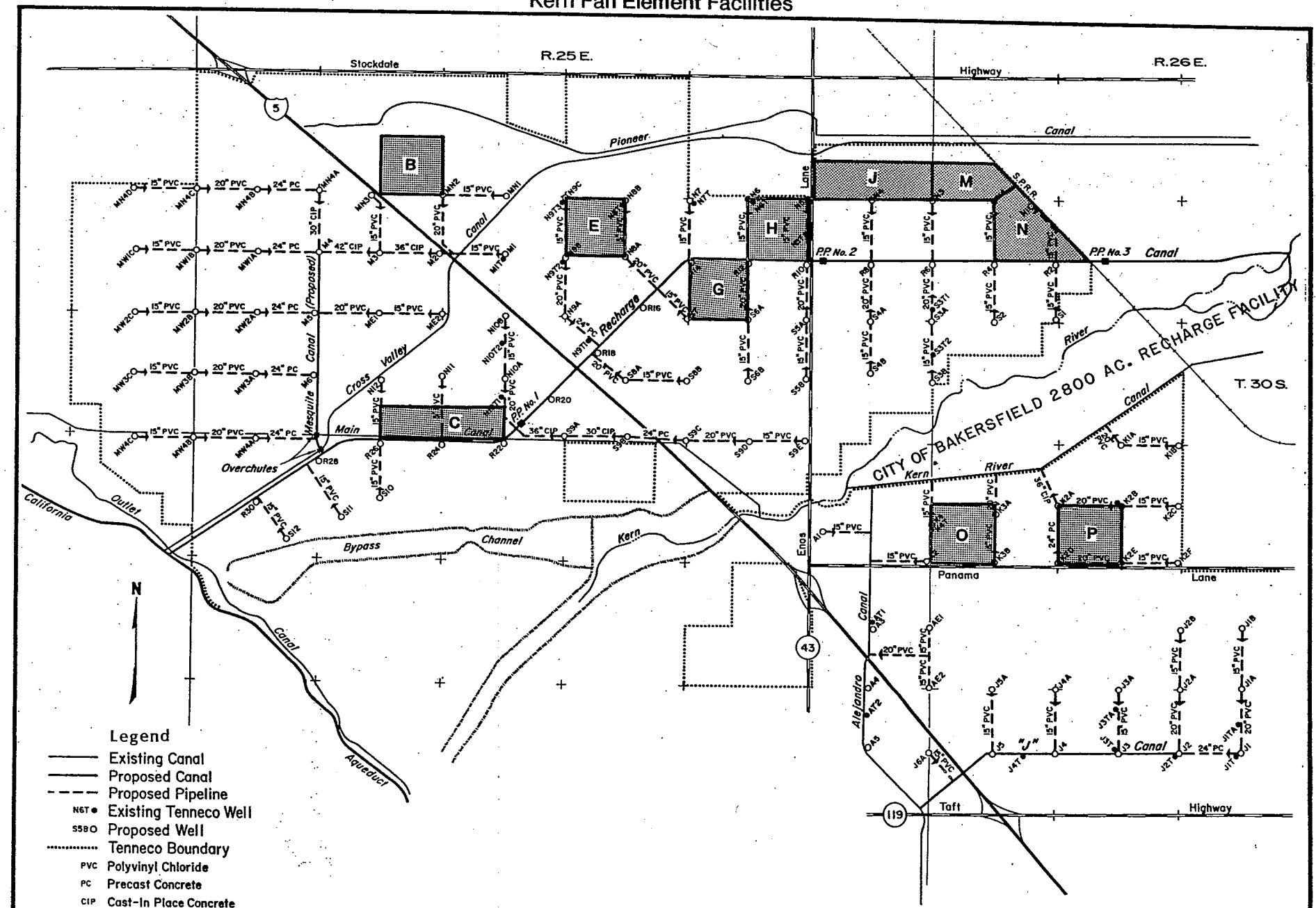
The Technical Report described a ground water storage project with a maximum storage of 1,000,000 acre-feet. Water was assumed to be conveyed from the California Aqueduct through a new State canal to the recharge basins on the property and to existing recharge basins in the adjacent City of Bakersfield's 2800-Acre Recharge Area. The State canal was proposed to have a capacity of 500 cubic feet per second. The proposed State facilities would have consisted of 1,600 acres of new recharge basins, and 110 extraction wells. Operating assumptions included a recharge rate of 30,000 acre-feet per month for nine months followed by a reduction to 25,000 acre-feet per month, and a sustainable extraction rate of 30,000 acre-feet per month (approximately 500 cfs). Most of the water would be conveyed back to the California Aqueduct through the new State canal, with a portion of the water pumped into the nearby Alejandro Canal for conveyance into the Buena Vista Aquatic Recreation Area Lakes and pumped back to the California Aqueduct through a proposed new pumping plant. Water supply studies of the proposed plan indicated an increase in SWP dry-period supply (firm yield) of about 145,000 acre-feet per year. Figure 1 shows the conceptual layout of the proposed facilities described in the Technical Report.

## PROPOSED ACTION

The proposed action is to develop the First Stage KFE of the KWB. The First Stage program will consist of operating six recharge basins covering 1,100 acres, along with 27 extraction wells, with a maximum ground water storage of 350,000 acre-feet. The First Stage will also involve use of the adjacent City of Bakersfield's 2,800-Acre Recharge Area. Operational experience with the First Stage program will provide the flexibility to configure and refine the location of future facilities before complete build-out.

# Figure 1 1987 CONCEPTUAL LAYOUT

## Kern Fan Element Facilities




(FIGURE 5 FROM APRIL 1987 PRELIMINARY TECHNICAL REPORT)

Geographic Information Systems ..... 83

4. **SIGNIFICANT EFFECTS OF THE PROPOSED PROJECT AND MITIGATION** ..... 85

Wildlife ..... 85
Ground Water Level and Quality Monitoring Program ..... 87
2,800–Acre Area Network ..... 87
KFE Monitoring Network ..... 92
Multiple Completion Wells ..... 92
Water Quality Monitoring Wells ..... 92
Recharge Pond Monitoring ..... 94
Subsidence Monitoring ..... 94
Regional Monitoring Network ..... 94
Water Quality Monitoring Program ..... 96
Produced Water Quality Monitoring ..... 100
Recharge Water Quality Monitoring ..... 100

5. **CUMULATIVE EFFECTS AND RELATED PROJECTS** ..... 101

Ground Water Recharge/Extraction Projects ..... 101
La Hacienda Program ..... 101
Goose Lake Slough ..... 102
1990 Demonstration Programs ..... 102
1987 Advance Storage Program ..... 102
KCWA 1990 Emergency Extraction Program ..... 102
Local Elements ..... 103
Local Uses of the Kern Fan Element ..... 103
Potential Impacts from Local Recharge ..... 103
Potential Impacts from Local Extraction ..... 106
Other Related Projects ..... 106
Metropolitan Bakersfield Habitat Conservation Plan (MBHCP) ..... 106
ARCO Oil and Gas Company —Bakersfield Arch Seismic Surveys ..... 108
Central Valley Habitat Joint Venture ..... 108
U.S. Naval Petroleum Preserve, No. 1 ..... 110

6. **ECONOMIC EVALUATION OF SERVICES AND PROJECT AREA ALTERNATIVES** ..... 111

SWP Service Area Economic Evaluation ..... 111
SWP Service Area Water Management Options ..... 112
South Coast Region ..... 112
Tulare Lake Region ..... 119
Sacramento River Region ..... 120
South Lahontan Region ..... 120
Colorado River Region ..... 121
San Francisco Bay Region ..... 121
Central Coast Region ..... 121

# Chapter 2. PROJECT DESCRIPTION

## GENERAL DESCRIPTION

This chapter describes the proposed project. Included in this description are the recharge and extraction facilities necessary for this program and the operational considerations to implement and operate the proposed project.

The Kern Fan Element (KFE) property, located in Kern County, southwest of the City of Bakersfield, covers about 20,000 acres. The principal components required to develop the First Stage facilities include: the construction of recharge and extraction facilities; the construction of service roads, canals, and pipelines; modifications to existing wells on the property; and construction of several new wells. To the extent possible, existing facilities will be used. The First Stage program has been planned for a maximum ground water storage of 350,000 acre–feet. Recharge facilities will provide a maximum recharge capacity of 90,000 acre–feet from November 1 through April 30. Extraction facilities will provide the capacity to extract 75,000 acre–feet annually. The First Stage recharge facilities will require use of about 1,100 acres of ponds on the property, as well as the adjacent City of Bakersfield's 2,800-Acre Recharge Area. The ultimate design and operation of the KFE will be based primarily on the operation of the First Stage program. Operation of the First Stage is designed to provide information and experience to help configure and locate future facilities and to provide the flexibility to refine operational parameters.

The First Stage will be operated initially under a concept of advance delivery of State Water Project (SWP) entitlement water (discussed later in this chapter). The general plan of the recharge, pumping, and conveyance facilities and the primary operating road network for the First Stage is shown on Figure 2.

Alternatives to the proposed project will be limited to relocating ponds and extraction wells within the KFE boundary. The development of alternative facilities outside the KFE lands for additional recharge opportunities is beyond the scope of this SEIR. The use of KFE lands by local water districts for recharge will also be considered. However, projects of this nature will require an agreement with DWR and KCWA and separate CEQA compliance before recharge and/or extraction will proceed.

A discussion of the proposed recharge and extraction facilities required for the First Stage is incorporated in the following sections. Additional information and description of these facilities are found in the Feasibility Report, First Stage, Kern Fan Element (December 1990) (Feasibility Report).

## RECHARGE FACILITIES

The City of Bakersfield's recharge facilities and six recharge basins on the KFE property will be used for the First Stage program. Water will be conveyed from the California Aqueduct

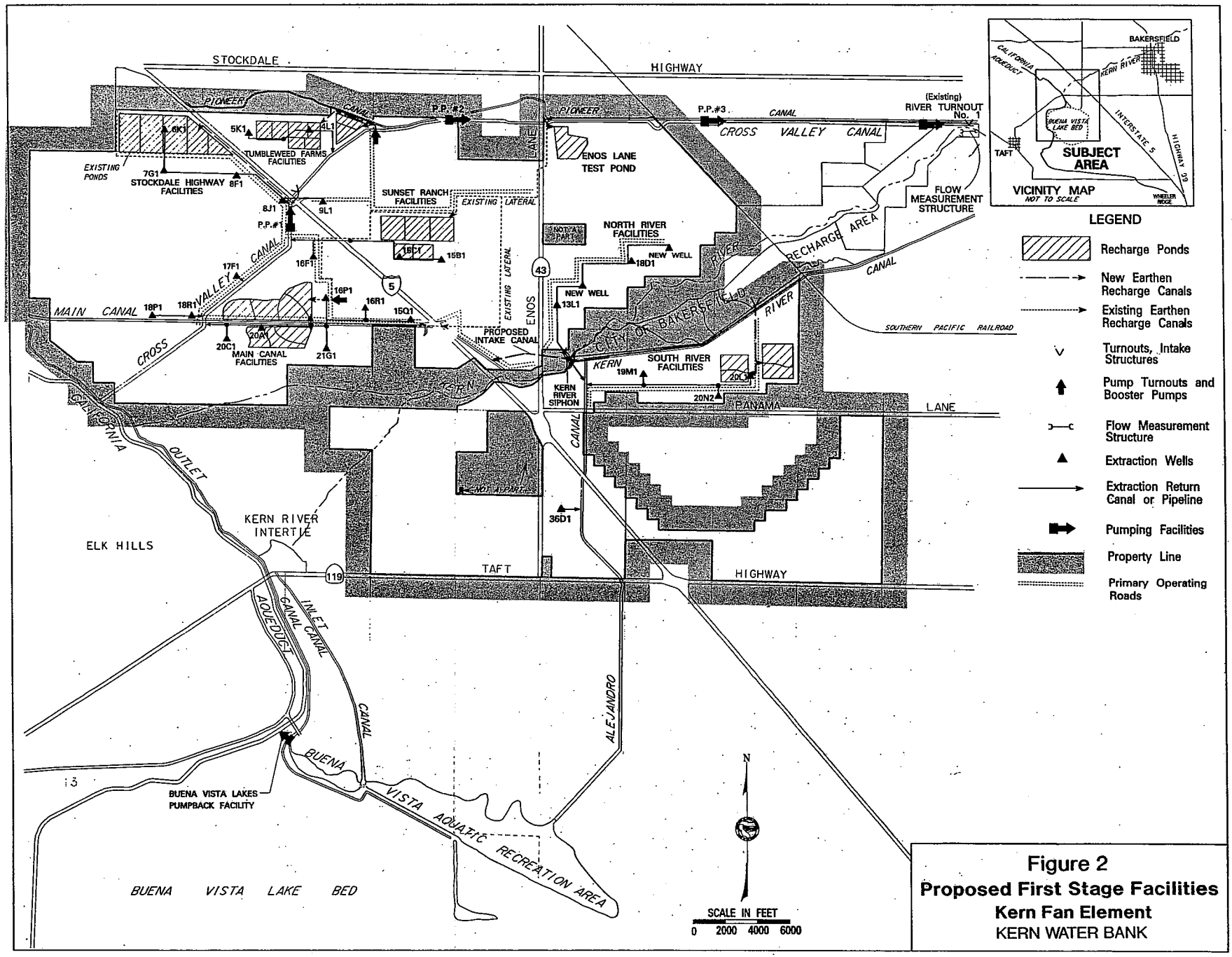



**Figure 2**
**Proposed First Stage Facilities**
**Kern Fan Element**
KERN WATER BANK

through the Cross Valley Canal (CVC) for recharge in both areas. Existing facilities to be used in the First Stage include: portions of the Pioneer Canal system and the Buena Vista Water Storage District Main Canal; the City of Bakersfield's 2,800–Acre Recharge Area; and an existing 320 acres of recharge basins in the northwest corner of the project area (the Stockdale Highway Ponds). New facilities and major rehabilitations include: five new recharge pond systems covering 790 acres; two gravity turnouts and one pump turnout from the CVC; a flow measurement structure below the CVC at River Turnout No. 1; a turnout from the City's ponds; a new intake channel for the Main Canal; a check structure in the Main Canal; two turnouts from the Main Canal; 1,400 feet of concrete lining of the Main Canal; a siphon under the Kern River Canal from the City's 2,800–Acre Recharge Area south to the KFE property; a connection from the City's 2,800–Acre Recharge Area via the Kern River to one of the KFE recharge sites; about 3.4 miles of new earth canals; and the rehabilitation of about 6.2 miles of the Pioneer Canal system laterals.

Separate negotiations are under way with the Buena Vista Water Storage District to develop agreements for use of the Main Canal, the Outlet Canal, existing spreading basins in the Tule Elk Reserve and other facilities to supplement the First Stage facilities. These facilities could provide extra recharge capacity in case of unexpected problems with First Stage recharge facilities, or if potential impacts of KFE extraction could affect nearby wells outside the property. Use of the existing Buena Vista Water District facilities will not require additional construction activity and therefore no other environmental documentation will be required.

Figure 3 shows a map of the pond sites and major recharge facilities for the First Stage program.

## Recharge Ponds

A summary of recharge pond statistics, including surface area and estimated long-term recharge rates is presented in Table 1. The Feasibility Report describes criteria used for selecting the recharge sites and defining their boundaries. One criterion used in the selection of pond sites was to avoid areas with known water quality problems or potential water quality threats until more is known about those areas. This decision resulted in locating no recharge ponds east of Enos Lane (Highway 43) and north of the Kern River, other than the Enos Lane Test Ponds. Preliminary water quality data suggests that the portion of the aquifer beneath the Enos Lane Test Ponds may have been contaminated by brine disposal activities in the nearby oilfields. If on-going exploration confirms suspected problems, the Enos Lane Test Ponds will be removed from the First Stage project. A second criterion was to locate First Stage ponds a minimum of 500 feet away from oil pipelines to avoid recharging directly over potentially contaminated soils and to restrict recharge mounding in the pipeline area.

For flexibility, the pond system is divided into operationally independent cells. By allowing independent cell operation, ponds can be dried out when recharge rates decline, allowing maintenance to be performed and thereby improve average long-term recharge rates. Adjacent cells can be operated on an alternate wet/dry cycle to maximize the recharge rate of the pond system. The cells were designed to fit the existing topography with a target average pond size of about 20 acres. Because of variations in topography, the pond cell sizes varied from a minimum of 12 acres to a maximum of 40 acres.

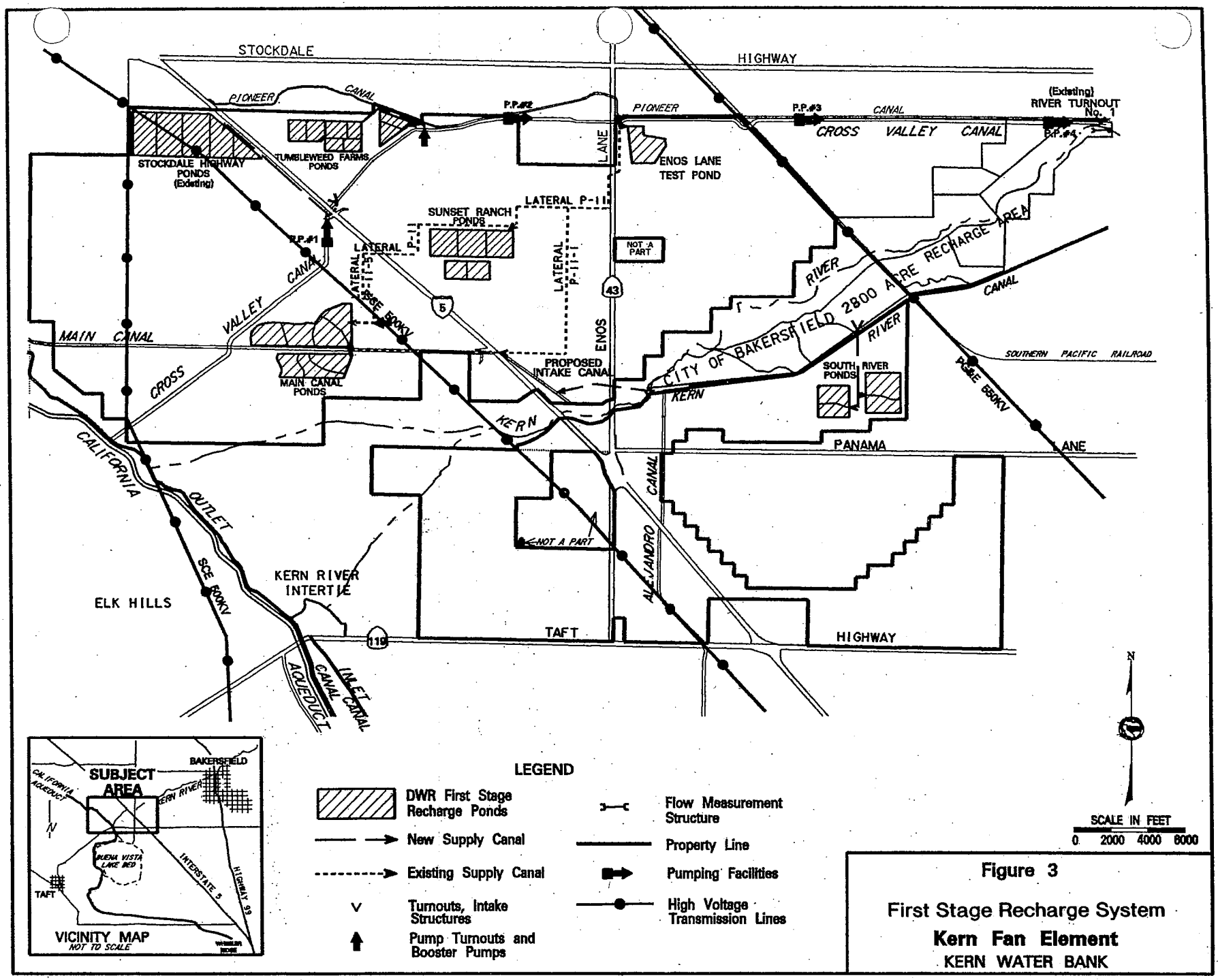



**Figure 3**

First Stage Recharge System

**Kern Fan Element**

KERN WATER BANK

**Table 1. Recharge Pond Characteristics**

| Pond Complex | Water Surface Area | Assumed Average Long-Term Recharge Rates | |
|---|---|---|---|
| | Acres | Cfs | Inches per day |
| Tumbleweed Farms Ponds | 164 | 20.5 | 3 |
| Stockdale Highway Ponds | 320 | 26.9 | 2 |
| Main Canal Ponds | 235 | 29.4 | 3 |
| Enos Lane Test Ponds | 38 | 4.8 | 3 |
| Sunset Ranch Ponds | 193 | 24.1 | 3 |
| South River Ponds | 160 | 20.0 | 3 |
| Subtotal | 1,110 | 125.7 | |
| City's 2,800–Acre Recharge Area | NA | 200.0 | NA |
| TOTAL | NA | 325.7 | or 19,600 AF/mo |

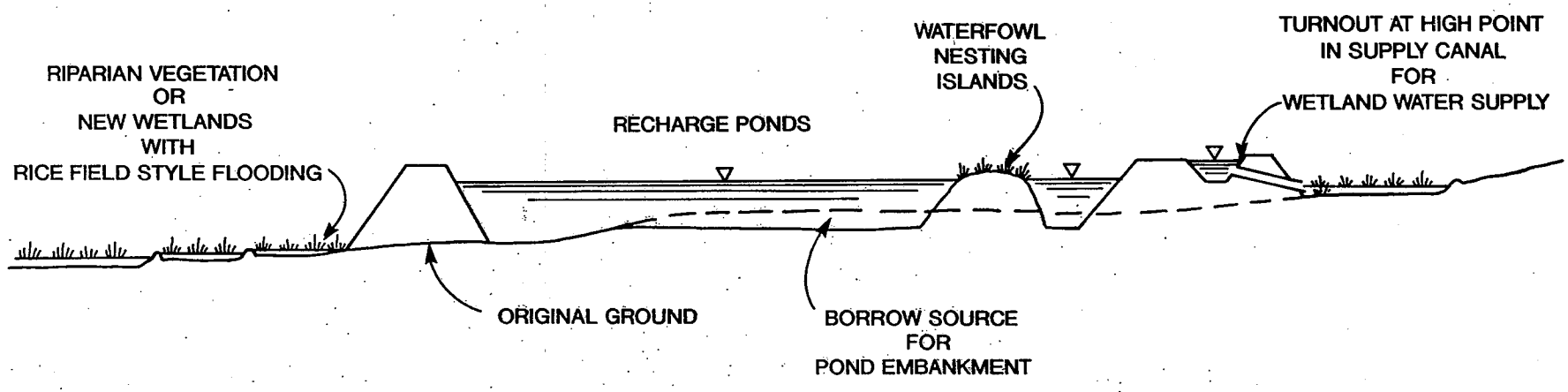
The existing 320 acres of recharge basins in the Stockdale Highway Pond System will require some modifications and improvements to correct embankment erosion damage and to provide better access to the Southern California Edison (SCE) transmission line towers. The five new recharge basins will be principally constructed on lands that are, or were recently, leased for agriculture. All embankment material to construct the recharge ponds and repair the Stockdale Highway Ponds will be borrowed from within the pond area.

Several measures are being considered to minimize wind erosion and dust problems, while sustaining recharge rates. Bermuda grass has been used successfully in nearby recharge facilities, and it appears to be the likely choice since it is easy to maintain.

Recharge rates for the various pond sites were estimated based on the experience of local agencies, soil surveys by the U.S. Soil Conservation Service, 50-foot hollow stem auger surveys by DWR, and site verifications with 20-foot hand–augured holes. With the exception of the Stockdale Highway Ponds, an assumed average long–term recharge rate of three inches per day has been used. While good recharge may be expected at the Stockdale Highway Ponds for relatively short-term recharge, recent DWR exploration indicates relatively extensive and impermeable clay layers under these ponds. Therefore, a more conservative long–term recharge rate of two inches per day has been assumed for this site.

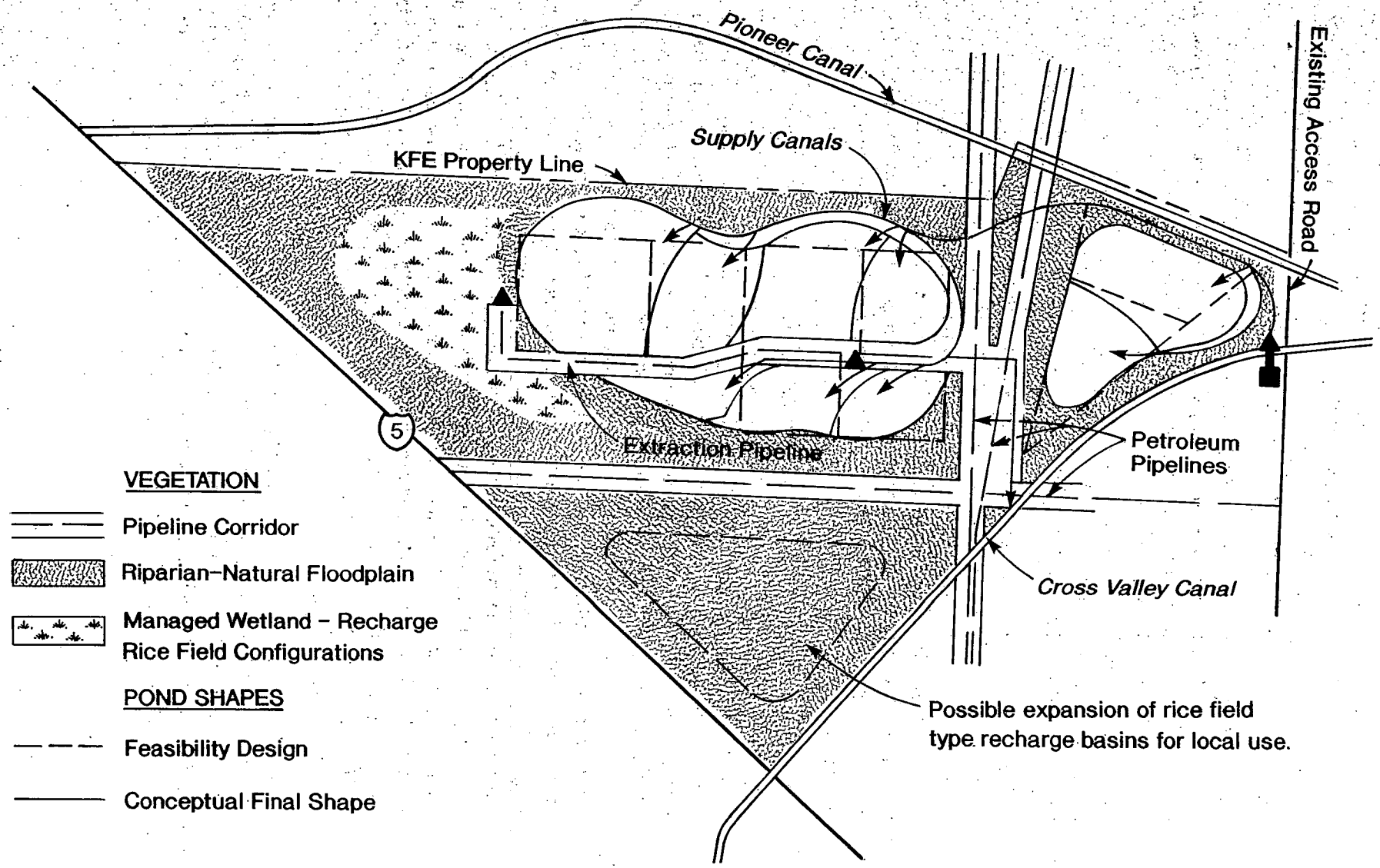
Much consideration has been given to the manner in which water will be recharged on the KFE property as part of the SWP recharge program. Early on there were discussions of providing shallow ponds that would follow the natural topography. This concept could reduce construction costs and provide additional wildlife benefits in the form of in-pond vegetation. This concept has been modified in favor of a concept that integrates relatively vegetation-free recharge ponds that are surrounded by riparian and wetland vegetation. A conceptual cross-section of a typical recharge

Figure 4
CONCEPTUAL CROSS-SECTION
TYPICAL RECHARGE BASIN




Not to Scale

FIGURE 5
TUMBLEWEED FARM PONDS
CONCEPTUAL PLAN



pond with the surrounding riparian-wetland vegetation is shown in Figure 4, and a conceptual plan is shown in Figure 5. The interior of the ponds would be managed to optimize recharge rates, minimize the area needed for recharge ponds, and minimize conflicts with wildlife. The surrounding vegetation would be managed for wildlife benefits.

The vegetated areas surrounding the ponds could be provided water supplies from both the recharge and extraction systems and managed primarily for wildlife benefits. These surrounding wetland and riparian areas could also be integrated into the designs for recharge facilities proposed by KCWA. These recharge programs would be based on much less frequent events of much shorter duration. Due to the desire to spread large amounts of water over as large an area as possible, the recharge facilities for these programs could have more potential for integration with the shallow pond and habitat concept than the First Stage KFE recharge facilities.

The KFE ponds would be relatively deep, with an average depth of about 2 feet and a maximum depth of 3 feet. These depths allow for the storage of the equivalent of about eight days of recharge at average long-term rates. The ability to vary the amount of water in storage will allow operational flexibility that will assist in maintaining average delivery rates, while selected ponds within are drained for maintenance. The pond storage will also provide the flexibility to deliver water at twice the average long-term recharge rates at times when excess water or delivery capacity exist.

With the exception of the Main Canal Ponds where the topography is somewhat irregular, preliminary pond designs have resulted in recharge ponds that are generally rectangular. In many instances, the shapes of the recharge pond groups were dictated by the location of the pipelines and property boundaries. It is expected that the shapes of the ponds will be modified in the final design process to develop more rounded random shapes with a natural appearance that blends with existing topography and local features. Naturally occurring topographical features will be developed to the extent practicable into vegetated islands that would be maintained as nesting habitat for waterfowl and other birds. (If desired, islands could be constructed in any of the pond groups at minimal cost.) The nesting islands could be provided in a selected cell for each of the groups. In addition to the islands, the selected cell could be graded and equipped with simple controls to maintain water in the immediate area surrounding the nesting islands. With the resulting configuration, water could be maintained at a controlled elevation in the portion of the pond surrounding the nesting island until the end of the nesting season (about the end of June). It is intended that water will be delivered to the recharge ponds, principally for ground water recharge. During SWP recharge years and locally wet years, the First Stage recharge ponds and their nesting islands would provide additional wildlife benefits at a small cost for the additional water supply required in April, May, and June.

Figure 5 shows suggestions for typical pond shapes and conceptual land uses to provide for recharge, wildlife enhancement, operation, and maintenance of new and existing facilities and other activities for a selected sample area, the Tumbleweed Farm Pond system. In addition to the ponds, recharge canals, extraction facilities, property boundaries, and other limiting features, the figure delineates areas appropriate for the following land uses categories:

- A mixture of riparian vegetation and other natural vegetation that could be found on the Kern Fan Element.
- A managed wetland habitat that would be developed in land graded similarly to an irrigated rice field. These lands could also provide recharge.
- Corridors along existing pipelines that would allow access for inspection and maintenance of the facility. These lands could be planted to dry-land crops, or access could be maintained via a gravel surface roadway.
- Areas with potential for rice field-type recharge basins for local recharge programs.

## Recharge Conveyance Facilities

The proposed conveyance facilities consist primarily of turnouts, earthen canals, road culverts, and other miscellaneous small canal structures. Five of the six recharge basin sites will be served by the CVC through new turnouts. The sixth site will be served via an existing CVC turnout and the City's 2,800–Acre Recharge Area.

New recharge system conveyance canals will be designed to the same standards as the existing Pioneer Canal laterals. New canal systems will be designed for twice the estimated long term recharge capacity of the pond systems they serve. Since water loss from the recharge canals adds to the recharge capability of the project, the canals will be of earthen construction with minimal compaction requirements. The bottom width and embankment top widths will be 10 feet to accommodate commonly used earth moving equipment. Canal sections are sized for a maximum velocity of 1.0 feet per second, 1.5 feet of freeboard and side slopes of 1.5 to 1.

Borrow material will be required to construct the new earthen canals. The borrow source will be adjacent agricultural fields. A shallow borrow operation that maintains existing drainage patterns or an alternative borrow operation designed to enhance the microtopography will be used to minimize the impacts on the land surface and local drainage. If borrow material is required from adjacent fallow fields, then DWR will initiate additional biological surveys to minimize adverse impacts to biological resources.

Standard conveyance canal structures include road crossing culverts, siphons under natural drainage channels and pipeline crossings, and check structures as needed to control the water surface will be provided. Siphons and culverts will be constructed of reinforced concrete pipe with reinforced concrete inlet and outlet structures.

The Stockdale Highway Ponds system will be supplied through a gravity turnout located downstream of CVC Pumping Plant No. 1 and Interstate Highway 5 (I–5). The turnout will discharge to the southeast of the CVC and will pass through an existing reinforced concrete pipe (RCP). The system is sized for a capacity of 100 cfs. About 3,700 feet of earthen canal will be constructed from the outlet of the RCP culvert to connect to the existing ponds. Minor modifications will be made to the existing ponds, including provision of adequate drainage for I–5 culverts, grading of existing embankments to repair erosion damages, and widening of ring dikes around SCE's transmission line towers to meet minimum SCE access requirements.

The Tumbleweed Farms Ponds system will be supplied from a new pump turnout located about 6,500 feet downstream of Pumping Plant No. 1. The new pump turnout will be comprised of two

xpumping units with a total capacity of about 50 cfs and a static lift of about four feet. About 3,700 feet of new earthen canal will be required to convey the water from the pump turnout to the two ponds in the system.

A third new turnout from the CVC will be located on the east side of Enos Lane. This will be a gravity turnout sized to deliver a total of 100 cfs. The Enos Lane Test Pond, the Sunset Ranch Ponds, and the Main Canal Ponds will be served by deliveries from this structure. Structural provisions will also be made to connect the Enos Lane turnout to the Pioneer Canal via the Lateral P-11 siphon under the CVC. This will allow use of the existing earth-lined Pioneer Canal as a recharge facility.

The Enos Lane Test Ponds will be connected to the Enos Lane turnout by about 800 feet of earthen canal. These ponds have been included with the First Stage facilities to test the recharge potential of a formation of permeable materials located in the northeast corner of the KFE property. These ponds are located near areas of potential contamination from pesticides, petroleum products, and oil well brine disposal. If the results of on-going explorations conclude that recharge in this area will exacerbate the existing water quality problems, these ponds will be eliminated from the First Stage program.

The Sunset Ranch Ponds System will be supplied from the Enos Lane turnout via existing Pioneer Lateral P-11. In order to meet the design water surface of these ponds, about 2,500 feet of Lateral P-11 will need to be reconstructed.

The Main Canal Ponds System will also be supplied from the Enos Lane turnout through the Pioneer Canal system. However, due to the limited capacity of the existing laterals, two routes will be used. The largest portion of the supply will be delivered through Lateral P-11-1 to the Main Canal. The water will enter the Main Canal through an existing structure near the northeast edge of I-5. The water will continue down the Main Canal to the east edge of the Main Canal pond complex. At this point a new control structure will be installed in the Main Canal, and turnouts will be constructed to deliver water to the pond systems on each side of the Main Canal. The total long term recharge rate for the Main Canal Ponds system is estimated to be about 30 cfs. Only 25 cfs can be delivered through Lateral P-11-1. To meet the anticipated recharge rate and provide some operational flexibility, an additional 15 cfs will be delivered to the north pond system via Pioneer Canal system Laterals P-11 and P-11-5. The connection from Lateral P-11-5 to the northeastern pond will be accomplished through an existing booster pump in Lateral P-11-5 connected to the ponds with about 1,100 feet of new earthen canal.

A portion of the Main Canal, near I-5, that will supply the Main Canal Ponds passes through an area where past petroleum leakage in the area of a Chevron oil pipeline has been observed. The portion of the Main Canal within 500 feet of the Chevron pipeline (1,400 feet) will be provided with a three-inch-thick concrete lining to minimize risks. The lined canal section will be sized for a capacity of 500 cfs to maintain the existing capacity of the Main Canal.

The new Main Canal Intake Channel will connect the Kern River and Buena Vista Water Storage District Main Canal. The new intake canal will replace an existing diversion weir and turnout that are inadequate for First Stage needs. This new Main Canal Intake Channel will begin at a turnout from the Kern River about 1,500 feet upstream of Enos Lane and immediately upstream from an existing diversion structure.

The City of Bakersfield's 2,800-Acre Recharge Area will be served from the CVC through existing River Turnout No. 1. This structure has a capacity of about 200 cfs and will supply the City's 2,800-Acre Recharge Area and the South River Pond System. Presently, there is no accurate means of measuring the discharge of River Turnout No. 1. As part of the First Stage the existing outlet structure will be modified and integrated with a new measuring weir. This structure has been designed and will be constructed by the Kern County Water Agency (KCWA). No additional work is needed to deliver water to the City's 2,800-Acre Recharge Area.

The South River Ponds system will be supplied from a turnout located at the southwest end of Pond No. 4 of the City's system. The connection to this system will require a 72 inch diameter pipe siphon under the River Canal and about 5,300 feet of earthen canal. The system will be designed for a maximum capacity of 100 cfs to provide adequate capacity for local use and future expansion of the recharge systems south of the river.

## EXTRACTION FACILITIES

The First Stage program will involve extracting recharged water from 25 existing wells and 2 new wells. Modifications and improvements of existing well pumps, motors and appurtenant equipment will be required. Most of these modifications and improvements will be done under the 1990 KCWA emergency well extraction program and the La Hacienda water purchase extraction program (see Chapter 5 for a discussion summary of these programs). Other modifications may result from refinements that occur during the final design process.

Extractions from 19 of the wells will be conveyed to the CVC. The extractions from the remaining 8 wells will be conveyed to the Alejandro Canal system. In addition to the two new wells, about 7.3 miles of buried pipelines (12- to 24-inch diameter), 6.6 miles of concrete-lined canals with 1- to 2-foot bottom widths and maximum depths of 3.5 feet, a siphon crossing of the Kern River, and a pump back facility at the Buena Vista Aquatic Recreation Area Lakes will be required. While no wetland or riparian habitat is expected to be disturbed, before constructing any facilities at the Buena Vista Aquatic Recreation Area Lakes, the area will need to be surveyed for the Buena Vista Lake shrew, a very sensitive species that, if present, may be potentially impacted.

The extraction wells and conveyance facilities have been divided into seven separate systems that will discharge directly to either the Alejandro Canal or the CVC. The seven systems are: (1) the Tumbleweed Farms system, (2) the Stockdale Highway system, (3) the Sunset Ranch system, (4) the Main Canal system, (5) miscellaneous CVC connections, (6) the North River Well system, and (7) the Alejandro Canal system connections. A map of the various systems and facilities is presented in Figure 6.

### Wells

All the existing wells, pumps, motors, and electrical systems will be rehabilitated and upgraded as needed. Most of the 25 existing First Stage wells have 16-inch diameter casings and are 700 feet deep. The average discharge potential for the 25 wells is estimated to be about 2,400 gallons per minute (gpm) per well.

Some of the existing wells used for the First Stage may be shared initially with agricultural lessees on the property prior to the end of 1993 when agricultural production is completely phased out.

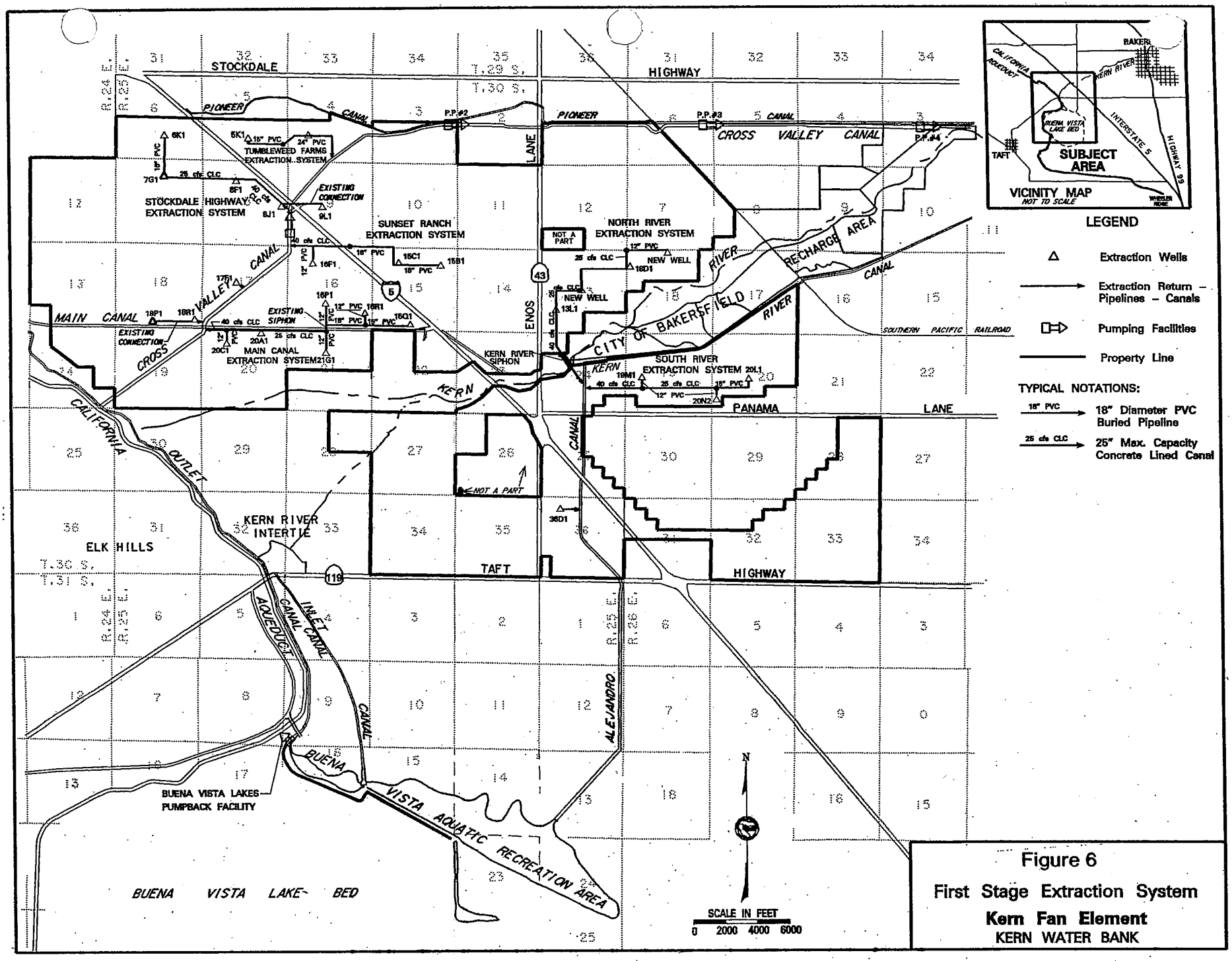



**Figure 6**

**First Stage Extraction System**

**Kern Fan Element**

**KERN WATER BANK**

There is the potential for conflict during the period that wells are shared. To avoid conflict, the pumps will be configured for low pressure discharge with the addition of temporary booster pumps that will attain sprinkler system pressures for the tenant systems using sprinklers.

Up to 80 percent of project recharge can be accomplished in the City's 2,800–Acre Recharge Area. Only five of the existing wells that will be used for extraction are located within one mile of the City's ponds. To lessen this imbalance, two new wells will be added in this area and will be constructed to the same depths and same general specifications as the rehabilitated wells.

Wildlife watering devices will be connected to each of the extraction wells. These devices will provide a source of water during extraction years to complement the water supply available to wildlife during recharge years from open canals, ponds, and adjacent wetland/riparian habitat. In years when neither recharge nor extraction occur, wetland/riparian habitat adjacent to the ponds could be operated to create an interim water supply to benefit wildlife.

## Extraction Conveyance Facilities

The proposed extraction conveyance facilities consist primarily of buried PVC pipeline, small concrete–lined canals, inlet structures at the Cross Valley and Alejandro canals, road culverts and other miscellaneous small canal structures.

Buried pipelines (with diameters between 12 and 24 inches) will be used for extraction facilities because they are relatively watertight and easier to maintain than open channels. Pipes will be buried to a depth of two to three feet. A minimum cover of two feet will be maintained except over the pipelines at crossings of the SCE transmission lines where the minimum cover will be three feet.

Small concrete-lined canals with one- to two-foot bottoms and depths of 3 to 3.5 feet will be used for conveyance facilities requiring pipes larger than 24 inches diameter. Two standard sizes are proposed for the extraction facilities: a one-foot bottom width section with a maximum capacity of about 25 cfs, and a two-foot bottom width section with a maximum capacity of about 40 cfs. The lining will be a minimum thickness of 3 inches.

Borrow material will be required for construction of the concrete lined canals. The borrow materials will be obtained from a shallow surface excavation that maintains existing drainage patterns or from alternative areas designed to enhance the microtopography. Impacts of the land surface drainage will be minimized. Locations and sizes of proposed new extraction system pipelines and concrete lined canals, as well as the proposed use of existing buried pipelines are shown in Figure 4.

The extraction facilities shown in Figure 4 are based on preliminary designs prepared specifically for the KFE. Since the completion of the preliminary KFE designs, final designs and specifications have been prepared for portions of the KFE extraction facilities that will be used for the La Hacienda Program. The final designs include 23 of the KFE wells and the conveyance facilities that connect 19 of the wells to the CVC. The La Hacienda facilities have been designed to achieve a greater degree of reliability and require higher average well discharges than envisioned for the KFE. For these and other reasons related to the La Hacienda Program, minor changes to the facilities shown in Figure 4 may occur.

Inlet structures to the Cross Valley and Alejandro canals will be similar to the systems used for the existing Olcese Water District and KCWA wells. A steel pipe will project over the edge of the

concrete lining and discharge into the canals through a 45 degree elbow directed downward and downstream at an angle of 45 degrees from vertical.

## Buena Vista Lakes Pumpback Facilities

At times, the extraction from the eight wells connected to the Alejandro Canal system will exceed the potential for exchange of SWP entitlements. In these instances the extracted water will flow to the Buena Vista Recreation Lakes and be returned to the California Aqueduct via the Buena Vista Lakes Pumpback Facility.

The facility includes an intake structure in the Buena Vista Recreation Lakes with a fish screen, a 72-inch diameter RCP siphon under the existing Rim Ditch, 600 feet of lined concrete canal, and a pumping plant. The pumping plant will be adjacent to the California Aqueduct with the discharge lines passing under the existing operating road. The plant will have outdoor units and will be similar in construction to the CVC pumping plants. The pumping plant has been sized for a capacity of 200 cfs at full project development with four 50 cfs units. For the First Stage, only two of the four pump units, discharge lines, and outlet structures will be constructed.

# OTHER PROJECT FACILITIES

To provide operational access to the new facilities and to connect each of the recharge pond systems and extraction networks to the existing state and county roads, an additional 17.4 miles of primary and 21.1 miles of secondary roadways will be constructed. Most of the primary road construction will consist of upgrading existing field roads or will be incorporated with other new facilities. The balance of the primary roads required will be constructed to minimize impacts to native habitat and/or areas known to be used by sensitive wildlife. The primary roads will have a 4-inch-thick, 20-foot-wide gravel surfacing.

The secondary roads will have a 4-inch-thick, 8-foot-wide gravel surfacing. The secondary road network will provide access from the primary road network to each well and to each control structure for the recharge ponds, the recharge conveyance system, and the extraction system. About 17.4 miles of secondary roads will be located on recharge pond and conveyance canal embankments. Another 3.7 miles of the secondary roadway network will be constructed between facilities or along buried pipelines.

Warehousing facilities may be needed for construction activities for the KFE project. These facilities have not been included with the First Stage facilities, and their impacts will be analyzed in the environmental study for the stage in which they are constructed.

***Climatic Monitoring Station.*** DWR will install a climate station on the KFE property to provide data for computing evaporation losses during recharge. An on-site climate station is essential for making reliable estimates of evaporation from recharge pond surfaces. In addition, a long-term record of weather data, collected under standardized conditions at the same geographic location, will be important to users throughout the southern San Joaquin Valley.

Possible locations for the climate station are shown in Figure 7. The station will occupy a ten acre site, with five acres consisting of irrigated and actively transpiring grass cover to provide a stable

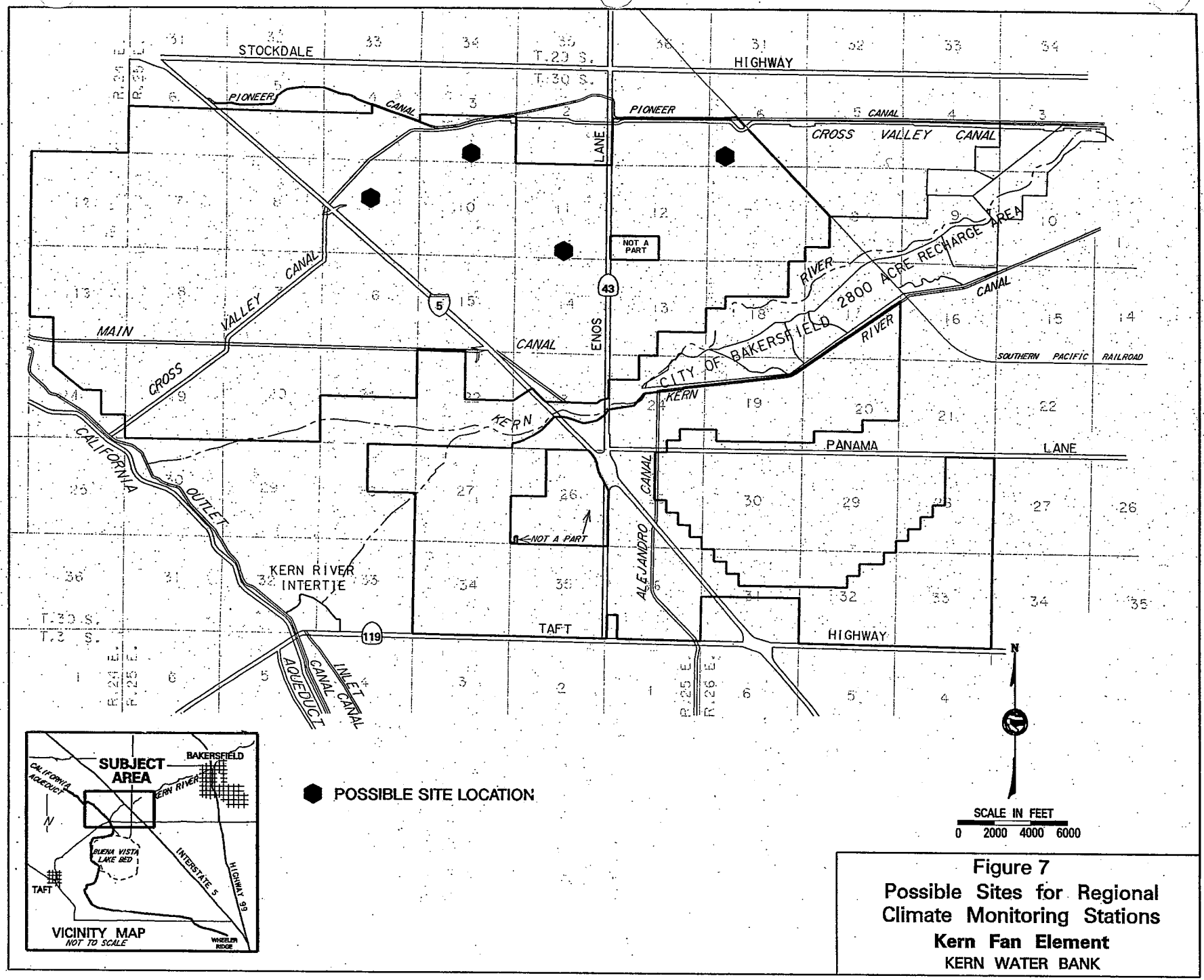



**Figure 7**
**Possible Sites for Regional Climate Monitoring Stations**
**Kern Fan Element**
KERN WATER BANK

environment for the instruments. The remaining five acres will remain unirrigated to allow measurement under "dryland" conditions. The following information will be collected for the irrigated environment:

- Solar radiation
- Air temperature
- Air humidity
- Evaporation
- Atmometer evaporation
- Wind speed at two miles
- Wind speed at 0.5 mile
- Wind direction
- Precipitation rate and amount
- Soil temperature at five standard depths
- Air pressure
- Drain gage Lysimeter

Evaporation, atmometer evaporation and soil temperature will be measured at the dryland site.

## ADVANCE ENTITLEMENT DELIVERY

During 1989, staff from DWR and the State Water Resources Control Board (SWRCB) discussed the need to amend DWR's SWP water right permits to accommodate operation of the KWB. SWRCB staff indicated that DWR would need to amend several provisions of its permits if DWR were to be directly storing and extracting water in a manner similar to present activities at SWP surface storage facilities.

Any modification of the existing water right permits is expected to take some time and may not be possible until after the Board's current Bay-Delta Hearings process concludes. Therefore, near-term implementation of any of the KWB elements is unlikely if water right amendments are required. However, SWRCB staff indicated that they would not object if a water contractor received the water from DWR and then stored and later extracted the water.

As a result of these discussions, staff of DWR, KCWA, and the State Water Contractors developed the concept of advance entitlement delivery, to be used for initial stages of the KFE and appropriate local elements. This concept allows early program features to proceed, with the full development of the KFE proceeding following necessary water right permit amendments. KCWA has stated that at the expected near-term level of State Water Project development and the range of deliveries expected under water-short conditions, there is a limit to the magnitude of a program that can be covered by advance entitlement delivery.

From a practical standpoint, water would be delivered to KCWA at the California Aqueduct turnout to the CVC at Tupman in recharge years. KCWA would take control of the water and transport it to recharge areas on either the KFE property or the City of Bakersfield's 2,800-Acre Recharge Area.

During extraction years, water would be pumped from wells on the KFE property and delivered to KCWA in exchange for a like amount of SWP entitlement otherwise delivered from the California Aqueduct for that year. Ground water withdrawals and subsequent delivery would count as the fulfilled "advance entitlement delivery," allowing a reduction in entitlement deliveries from the Aqueduct. Extracted water would be exchanged for water that would have been delivered in either the CVC or the Alejandro Canal systems for local use to the extent possible. At times, some of the water will need to be returned to the Aqueduct for delivery to KCWA member units segregated from the KFE property. This is consistent with the advance delivery concept, since KCWA pays for and uses that portion of the California Aqueduct to distribute SWP water to its member units.

Extraction from the First Stage will be limited to the capabilities of the wells in the extraction system. Use of the 27 wells with conservative assumptions as to long-term pumping capacity results in an annual extraction capability of about 75,000 acre-feet per year, which is subject to deficiencies in water-short years. Almost 90 percent of this amount is for agricultural use, which is subject to the first level of deficiencies under the SWP water supply contracts. It would take a very severe SWP water delivery deficiency with almost full deficiencies to agricultural use to jeopardize the extraction of First Stage water as advance delivery of entitlement. Nonetheless, it is expected that appropriate changes in DWR water right permit conditions will be sought in the next few years for long-term operation of the First Stage, subsequent KFE expansion, and local elements.

Provisions for advance delivery of entitlement will be incorporated in the operating agreement between KCWA and DWR. Similar provisions will be incorporated into the agreement among KCWA, DWR, and the City of Bakersfield for use of the 2,800-Acre Recharge Area and the Kern River Canal.

## KERN FAN ELEMENT OPERATIONS

Operation of the First Stage is planned to provide information and experience to help in refining future operations and to identify operational problems. The ultimate design and operation of the KFE will be based to a large extent on experience with the First Stage.

The First Stage has been planned for a maximum ground water storage of 350,000 acre-feet. Recharge facilities will provide a maximum recharge capacity of 90,000 acre-feet in a six-month period — November 1 through April 30. Extraction facilities will provide the capacity to extract 75,000 acre-feet annually.

Under an agreement (to be negotiated) between DWR and KCWA, DWR will manage the general scheduling of deliveries to and from the KFE (as well as all other potential elements of the KWB), while KCWA will operate the KFE Facilities at DWR's direction.

### Recharge Operations

Water will be delivered to the KFE during wet years from the SWP's Oroville and San Luis reservoirs and the Sacramento–San Joaquin Delta via the California Aqueduct to the CVC turnout at Tupman. From the CVC, water will be diverted to six KFE recharge basins and the City of Bakersfield's 2,800–Acre Recharge Area. The First Stage facilities will be designed to accommodate an average annual recharge rate of 90,000 acre-feet.

The City's recharge facilities presently have an estimated maximum annual recharge capacity of 200,000 acre-feet. The City has first priority to spread water in the area, and permits KCWA and other local water districts to spread and extract water through separate agreements. Under the proposed joint operating agreement with the City of Bakersfield, the City's 2,800-Acre Recharge Area would be available for use by DWR when it is not being fully used for local recharge. A review of monthly hydrology on the Kern River and the operation of the 2800-Acre Recharge Area indicates that the facility would have available capacity to recharge SWP water at least 90 percent of the time.

Priority for KFE recharge will be given to new recharge systems that are closest to the CVC in order to minimize the CVC user fees and power costs. The first priority for recharge will be given to the rehabilitated Stockdale Highway Ponds, second priority to the Tumbleweed Farms Ponds, third priority to the Enos Lane Test Ponds, Sunset Farms Ponds, and Main Canal Ponds, and the remaining recharge delivered to the City's 2800-Acre Recharge Area. Deliveries from the City's ponds to the South River ponds will be made once inflow to the ponds exceeds the accumulated recharge through the City's Pond No. 4 and water is available to divert.

The proposed agreement with the City for use of the 2,800-Acre Recharge Area requires that a minimum of 10 percent of the total recharge take place on the City's facilities. At the estimated capacity of the First Stage recharge ponds, about 60 percent of the recharge must be done on the City's facilities to achieve the total project recharge capacity of 15,000 acre-feet per month.

The proposed joint use agreement for the City's Ponds requires the First Stage recharge facilities be used for the recharge of Kern River water to the extent that KFE operations in the City area have diminished recharge capability that otherwise would have been used by the City and its spreading contractors. The proposed South River Ponds and Main Canal Ponds (via the new intake canal) can be used to satisfy this requirement. Monthly operations will be carefully monitored to ensure that the amount of any impairment to the City's recharge is within the capabilities of providing compensating recharge on the KFE property.

The use of the City's area for recharge offers an opportunity for a water exchange. Through exchanges with local purveyors, SWP water could be exchanged for a like amount of local water (primarily Kern River Water) for recharge in the 2,800-Acre Recharge Area. Such exchanges could result in savings in user fees and power costs.

Due to capacity limitation of River Turnout No. 1, the recharge capacity of the City's ponds for SWP water will be limited to a maximum of 12,000 acre-feet per month. The estimated capacity of the recharge ponds on the KFE totals about 7,600 acre-feet per month. The total recharge capacity will therefore exceed the total needed capacity by 4,600 acre-feet per month, or 30.6 percent. This will allow any one of the six recharge pond sites on the KFE property to be taken out of service and the needed average monthly recharge rate maintained.

During recharge operations of the KFE, some portion of water delivered from the California Aqueduct will be lost. Two general types of losses are expected to occur: transportation losses in delivery of water from the Aqueduct to the recharge basins and operational losses in the recharge basins themselves. Transportation losses consist of seepage over unusable ground water areas and evaporation from conveyance facilities. Operational losses are expected to occur in the recharge

basins through evaporation from ponded water surfaces, phreatophyte use, and bare soil surface evaporation. Recharge basin losses constitute the bulk of the operational recharge losses.

Transportation losses during the First Stage are assumed to be minimal. The primary recharge conveyance facility during the First Stage will be the CVC, which passes over about one–half mile of higher salinity (greater than 1,000 mg/L total dissolved solids) ground water adjacent to the Elk Hills. Seepage losses in this stretch of the CVC will be treated as operational losses

First Stage losses are expected to range from about four percent for winter recharge to about seven percent for year-round recharge operations. The computation of recharge losses is explained in Appendix F of the Feasibility Report.

## Extraction Operations

The planned maximum annual extraction rate for the First Stage is 75,000 acre–feet. Extractions will be made from the KFE during dry times in the SWP system. Stored water will be extracted at a uniform monthly rate through the use of the 27 production wells. Most of the wells will be connected for delivery into the CVC. Eight of the 27 wells will be connected to the Alejandro Canal. These wells are closest to the City's recharge facilities and effect the most direct use of the majority of the First Stage program recharge. These wells constitute about 30 percent of the project extraction capacity in comparison to the 60 percent of the total recharge accomplished through the City's facilities. Consequently, these wells are assumed to be run at full reliable capacity. To meet the uniform monthly extraction demands of 6,260 acre-feet per month for the First Stage program at the estimated average production capabilities, only 19 of the new and rehabilitated wells would be necessary. The 19 wells that discharge into the CVC will be operated at somewhat less than full capacity to meet the remaining portion of the project commitments. Lowest use would be given to the wells in the Main Canal system to avoid impacts to the nearby West Kern Water District well field.

Preliminary studies indicate that there should be adequate exchange potential to absorb the extractions from the 19 wells connected to the CVC. Additionally, the need to return extractions from the CVC to the California Aqueduct for local exchange is not anticipated for the First Stage operations. Since no definitive long term need has been identified for the First Stage program, neither temporary or permanent facilities to return water from the CVC to the California Aqueduct have been studied in detail.

The extractions from the eight wells connected to the Alejandro Canal will be delivered to the Buena Vista Aquatic Recreation Area Lakes. When the capacity for exchange exists, the extraction water will be exchanged with the Buena Vista Water Storage District and the Henry Miller Water District. The exchange would be made for SWP entitlement deliveries that would normally be delivered via the California Aqueduct to the Buena Vista Lakes. Since these water districts are on an agricultural demand schedule and the extractions are made at a uniform rate, there will be times during the year when exchanges are not feasible. In water-short years the entitlement will be reduced for deficiencies and the extractions will often exceed the reduced entitlement. This situation will also reduce the potential for exchange. In these situations, the water will be returned to the California Aqueduct via the Buena Vista Lakes Pumpback Facility. Estimates based on SWP 3.7 MAF level demands indicate up to 58 percent of the Alejandro system extractions could be returned to the California Aqueduct. Meeting the 6,260-AF-per-month extraction demands on the

First Stage program at the estimated average production capabilities would require only 19 of the new and rehabilitated wells, which would translate to a required reliability factor for the wells of about 0.70.

## OPERATING CRITERIA

The basic KFE operating rules are summarized below:

| Parameter | Criteria |
|---|---|
| Maximum recharge rate | 15,000 acre–feet per month |
| Annual recharge period | November – April |
| Maximum extraction rate | 6,200 acre–feet per month |
| Extraction months | Year–round |

Beyond these basic rules are a number of operating criteria that will determine the water supply benefits from the program, as well as the local impacts. At this stage of project development, these rules are for planning and discussion. More detailed and/or revised operating criteria will likely be developed as the project moves into operation. The criteria are divided into recharge and extraction categories.

### Recharge Operating Criteria

A key goal of the First Stage is to gain as much experience as possible operating recharge ponds at various locations on the property. This experience is expected to provide necessary information for expansion of the KFE to its ultimate storage, recharge, and extraction capacities as set forth in the Program EIR and Technical Report. First Stage recharge facilities are planned to be located at representative sites on the property. Another goal, as set forth as a requirement in the draft agreement for the joint use of the City of Bakersfield's recharge facilities, is that, over the life of the agreement, a minimum of ten percent of KFE recharge will be recharged in the City's facilities.

No problems are expected in meeting either of these goals. The First Stage is proposed to be operated in a six–month recharge mode, with maximum monthly recharge of 15,000 AF. Using conservative assumptions regarding expected recharge rates for designated areas on the KFE property, roughly 40 to 50 percent of monthly recharge is expected to occur in DWR recharge sites. The remaining will be recharged in the City's facilities. These recharge percentages are expected to be changed in the future by constructing additional recharge facilities on KFE property in a subsequent stage of project development. The percentages could also be changed if the recharge period were expanded or contracted.

### Extraction Operating Criteria

The goal of extraction is to sustain adequate long–term pumping rates at each of the wells and avoid significant adverse impacts to surrounding ground water users. Extraction will occur when the SWP annual operating rules (Risk Curve) require that withdrawals from ground water storage be made. It is anticipated that extraction in the first year of a dry period would begin in March and continue month–to–month as long as needed. Based on the historical recurrence of dry years, most extraction periods would be two years or less. The exception to this is the 1928–1934 drought period, which is a primary basis for design and operation of SWP facilities. During this seven-year period, extraction would occur nearly continuously, with several months of recharge during the winters of 1930 and 1932.

# Chapter 3. AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

The comments received on the Notice of Preparation for the First Stage Kern Fan Element program conveyed interest regarding potential effects on water quality, wildlife, and wildlife habitat. The Department of Water Resources agreed, as part of the KFE program discussed in the 1986 EIR, to include a plan in the KFE development that would allow lands not actively used for recharge to revert to native habitat. Vegetation and wildlife studies are currently being conducted to inventory the status of species on the KFE property.

DWR acknowledges that sensitive wildlife species are present on the KFE property and that the construction of the KFE facilities will result in impacts to wildlife. These impacts will be fully mitigated within the KFE boundaries and in compliance with CEQA and other applicable regulations. In addition, the net long-term effect of converting the remaining KFE lands that are not reserved for recharge and extraction to native habitat (both wetland and upland) will be beneficial to wildlife, especially to threatened, endangered, and sensitive species that have been jeopardized by human disturbance and/or agricultural activities in this area.

Since some of the issues raised in the Notice of Preparation were not evaluated in the Program EIR, those issues will be examined in this document. This chapter describes the affected environment and sets forth those environmental matters that would potentially be impacted by implementation of the proposed project. Included are the results of the water supply studies and the resulting impacts on SWP operations and water deliveries; a discussion of the resulting increases in diversions from the Sacramento-San Joaquin Delta; a discussion of ground water basin water quality and the quality of water to be recharged and extracted; a discussion of potential impacts on local and regional ground water levels; a description of wildlife and vegetation and the potential impacts to those resources; and a description of existing land uses on the KFE property and how land uses may change in the future.

## WATER SUPPLY STUDIES

First Stage deliveries to storage will occur from November to April. The First Stage has the capability of storing a significant amount of excess Delta flows and improving the delivery capability of the SWP. Excess Delta flow is water not subject to prior water rights and not needed to meet Delta water quality requirements. The First Stage is also capable of receiving storage transfers from Oroville and San Luis Reservoirs so that these reservoirs can capture additional runoff.

The additional water that can be delivered as a result of the proposed project is determined by modeling SWP operations. Operation studies are conducted to evaluate the existing or pre–project

water supply capability to define a "base case" condition. Studies are then conducted with the proposed project integrated with existing SWP facilities. The difference between the two capabilities is the additional water supply that would be developed as a result of the proposed project.

Water supply studies are performed using DWR's planning simulation model - DWRSIM. This model simulates the monthly operation of the SWP and Central Valley Project (CVP) system of reservoirs and conveyance facilities. It is a key tool for planning new facilities to meet California's future water needs. The model accounts for various capacity restrictions, reservoir operating criteria, wheeling agreements, instream flow requirements, water quality requirements, Delta export limitations, losses, and other related factors that might affect storage levels and flows in the system.

The studies performed for the First Stage evaluated the operations of the project at three future levels of SWP annual delivery requests:

- 3.5-million-acre-foot request
- 3.7-million-acre-foot request
- 4.2-million-acre-foot request

Model simulations used the historic hydrology for the 57-year period, 1922 to 1978, with adjustments to reflect present or future land use and other factors.

The proposed project was evaluated in two operational modes. The first assumed that recharge and extraction would operate within the total storage limit of 350,000 acre-feet. The second operational mode used a "surcharge" concept, whereby an annual encroachment of 50,000 acre-feet above the 350,000 acre-feet limit was allowed, with a requirement that this water would be pumped out and delivered during the same year. This annual encroachment, or "surcharge", was evaluated to determine if additional water supply accomplishments could be gained, and to demonstrate an alternative way in which a ground water program could operate. No specific detailed operational rules have been developed to refine this concept further.

Initial water supply study assumptions were developed in late 1989. At that time, it was decided to perform water supply studies at the three different levels of future SWP entitlement delivery demand. This provided a range from near-term demands when the KFE could be operational to the long-term maximum demands provided for in the water supply contracts. Assumptions were developed for additional specific SWP facilities that were expected to be operational to help meet those future demands. Such facilities included completion of the additional pumps and the SWP Banks Delta Pumping Plant, and development of the South Delta Improvements to allow full use of the additional pumps.

A more difficult matter is the assignment of years when these events were assumed to occur. In recent years, long-term requests for entitlement deliveries have been increasing. In fact, the demand of 3.5 MAF in the first level of the water supply studies corresponds to the level of SWP contractor requests for 1995 in the recently published DWR Bulletin 132-90, but it also corresponds to the requests submitted in the fall of 1990 for deliveries during 1991. Near-term requests for delivery of entitlement are fairly likely to vary in accordance with near-term prevailing water supply circumstances. Through much of California, 1990 represented the fourth consecutive dry year.

While the water supply studies were conducted at the three future demand levels, there is no absolute certainty as to when these levels of request would be reached. Initially, the years assigned to each demand level used in this study were based on the water delivery requests published in DWR Bulletin 132-90. Subsequent requests from SWP water contractors received in fall, 1990 (to be published in Bulletin 132-91 in fall, 1991) indicate that the near-term levels of demands could be reached sooner than assumed.

Given lack of absolute certainty concerning near-term SWP entitlement delivery requests, this report assumes that near-term requests at specific levels will be reached some time during the period of years shown below:

| *Demand Level* | *Period During Which Demand Level Is Reached* |
|---|---|
| 3.5 MAF per year | 1991 – 1995 |
| 3.7 MAF per year | 1996 – 2000 |
| 4.2 MAF per year | 2010 and thereafter |

A further matter is the set of assumptions used in these studies regarding timing of future SWP facilities. Completion of the four new pumps at the Banks Delta Pumping Plant is assumed for the 3.5 MAF studies (operated under existing pumping limitations), since these facilities are scheduled to be completed and operational in late 1991. Channel improvements and facilities in the South Delta (referred to as South Delta Improvements) are assumed to be completed and operational by 2000, but they do not show up in these studies until the 4.2 MAF demand level. This is because studies at the maximum contractual demand level of 4.2 MAF were needed, and no intermediate studies were made with the South Delta Improvements in place at lower demand levels.

The actual years assumed in the studies for demand level attainment have no effect on the water supply accomplishments output from each study. The studies just look at the demand levels and specific assumptions (including assumed future facilities). Specific years assumed for each study level have importance only in the evaluation of economic long-term benefits and costs in the SWP service areas.

The historic measure of the SWP's delivery capability has been the concept of "firm yield" operation. Defined in the water supply contracts as "minimum project yield," firm yield is the dependable annual water supply that can be made available without exceeding specified reductions ("deficiencies") in agricultural deliveries during extended dry periods. More specifically, firm yield has been classically defined as the maximum reliable amount of water that could have been delivered by the SWP to its water contractors during a recurrence of the historic seven–year dry period (1928–1934), subject to deficiencies applied under water contract criteria. Under past planning period assumptions, the firm yield amount would be delivered in several of the seven drought years, while deliveries in the remaining years would be less than this amount. The firm yield of existing SWP facilities historically has been calculated to range from 2.3 to 2.4 million AF per year. Since 1987, contractor requests for entitlement water have exceeded that amount.

In addition to the development of new project facilities to increase water supplies, DWR and the SWP water contractors have been examining alternative operational strategies to improve the average annual delivery capabilities. Particular attention has been focused on using an alternative

method of operating the SWP. This method involves using water supply forecasts and analysis of the risk of varying delivery amounts and hydrology to determine project deliveries under most conditions. Since 1978, operational decisions for the SWP have been based on an annual analysis of the risk of delivering more project water and carrying over less storage to meet future needs. Such a risk analysis provides a rational means of deciding how much water to deliver in a given year and how much to leave in storage to provide for subsequent dry periods. This has led to operating the SWP in a manner that does not seek to preserve "firm yield" for delivery during a repeat of the historic seven-year drought of 1928-1934. Rather, the SWP is now operated under an increased-risk concept (the "Water Delivery Risk Analysis," or Risk Analysis), which currently favors maximizing deliveries over a shorter drought period. Consequently, the return of the 1928–1934 drought cycle could reduce SWP deliveries to amounts less than those determined in earlier studies based on firm yield.

With the various possibilities in the delivery logic, it has become increasingly more complex to define the water supply benefits of a proposed future project by any one measure. The measures used in this report are: (1) the "average annual dry period supply" (explained below); (2) the average annual deliveries over the 57–year study period; (3) the average increase in deliveries during the 57–year period in years when improvement is possible; and (4) the potential changes in SWP operational flexibility resulting from the proposed new facility.

The average annual dry period supply (AADPS) is the average annual amount of increased SWP deliveries during the seven-year drought from March 1928 to February 1935 resulting from a proposed new SWP facility. The measure of delivery capability during this period has been the foundation for statewide water development in California for more than 50 years. Past use of the firm yield numbers is still in many people's minds. While the SWP is no longer operated on that basis, there is some interest in comparing past "firm yield" numbers to amounts calculated as AADPS. Firm yield is the *maximum* delivery in any one year during the 1928–1934 period (assumed in past studies to occur in three or four of the seven drought years) from which delivery deficiencies are applied, while the AADPS is simply the numerical *average* annual delivery during this same period. Firm yield studies did not use the Risk Analysis concept, while the AADPS numbers in this report are based on Risk Analysis operations. Unfortunately, firm yield and Risk Analysis operations and study results are not directly comparable, because the operational concepts differ and there is no consistent numerical relationship between the two. In some studies, the numbers are about the same. In other studies, there has been a difference of up to 20 to 30 percent. In addition, the firm yield and Risk Analysis concepts result in different reservoir operations, including changes in occurrence of reservoir spills and patterns of storage. Any comparison of firm yield numbers and AADPS numbers from a Risk Analysis study would require taking into account any differences between the studies in reservoir storage amounts.

At present, the SWP is operated on a year-to-year basis under the Risk Analysis concept. While the studies in this report assume Risk Analysis operation at future entitlement demand levels, no judgment or conclusion is made in this report as to the need for any future changes in the water supply contracts to reflect this operational mode.

The operation studies for the First Stage were conducted similarly to those prepared in the April 1987 "Preliminary Technical Report," with some changes in the operating criteria. Modifications

were made to reflect the recharge and extraction operation of the scaled-down project and the Risk Analysis operating procedures.

An objective in the water supply studies is to develop the greatest water supply benefits for the SWP within acceptable operating criteria. A new SWP storage project provides additional water supply benefits by providing more flexible operations for the entire SWP. It allows the SWP to store additional water that would not otherwise have been captured during wet periods. Historically, there have been many wet years in which Oroville Reservoir has been at full storage capacity and had to release water for flood control. During similar future periods, integration of new storage projects south of the Delta (such as the KFE) will allow the SWP to capture some of this excess water. In dry periods, increased storage and delivery capability of new storage projects will allow the SWP, as a whole, to deliver more water. New south-of-the-Delta storage projects also increase the probability of delivery in future years by transferring water from the northern SWP reservoirs to south-of-the-Delta storage before the wet season so that northern storage is available to capture more water. There is, therefore, a lesser degree of risk in releasing more water from storage than would have occurred without the project. In addition, new south-of-the-Delta storage facilities allow the SWP to divert and store more excess winter Delta flows.

A detailed description of the water supply studies is set forth in the First Stage Kern Fan Element Feasibility Report (December 1990).

## Impacts on SWP Delivery Capability

The water supply accomplishments are summarized in Table 2. For the 3.5 MAF demand study, the First Stage increases the AADPS by 52 TAF and the 57-year average by 31 TAF. Results of the delivery capabilities for the surcharge operation are also shown.

**Table 2. First Stage Kern Fan Element Water Supply Study Results**
**In 1,000s of acre-feet**

| | Level of SWP Demand, in MAF | | |
|---|---|---|---|
| | 3.5 | 3.7 | 4.2 |
| **No Surcharge** | | | |
| Average Annual Dry Period Supply (AADPS) | 52 | 54 | 70 |
| 57-Year Average | 31 | 44 | 56 |
| Average Delivery Increase in Years That Improvement Is Possible | 59 | 68 | 72 |
| **Surcharge Operations** | | | |
| Average Annual Dry Period Supply (AADPS) | 52 | 54 | 72 |
| 57-Year Average | 33 | 49 | 68 |
| Average Delivery Increase in Years That Improvement Is Possible | 64 | 73 | 84 |

Figure 8 shows an increasing trend for several measures of SWP delivery capability. The AADPS increases from 52 TAF in the 3.5 MAF demand study to 70 TAF in the 4.2 MAF demand study. This increase occurs primarily due to the combined benefits of other proposed future SWP facilities. A key example is the completion and ultimate maximum operation of the four new pumps at

the Banks Delta Pumping Plant. There are several short wet months during the 1928–1934 dry period. The additional Delta pumping capacity could be used to recharge additional water during 1930 and 1932 for later delivery by the end of 1934.

Similar increases are noted for the 57-year average annual delivery increase in the studies, from 31 TAF in the 3.5 MAF demand study to 56 TAF in the 4.2 MAF demand study. There are two primary explanations for this increase. The first is that delivery demands are increasing over time, resulting in an increase in frequency when deliveries *would not* be fully satisfied. Over time, there is greater capability for the kind of water supply improvement that the KFE could provide.

The studies show that use of KFE storage would increase over time to meet these projected increased delivery deficiencies. The second explanation is that water supply benefits would increase from combined operation of future SWP facilities, as described above.

An additional measure is the average delivery increase in years that increased delivery is possible. While the 57-year average increase in deliveries is an important water supply measure, it includes years when all SWP demands would be met, even without the KFE. There, the 57-year average includes years when no delivery increases were needed. The number of years that full demands are met is expected to decrease as SWP demands increase. This measure of benefits was 59 TAF in the 3.5 MAF demand study, and it increased to 72 TAF in the 4.2 MAF demand study.

The "average delivery increase in years that increased delivery is possible" is a measure of benefits provided in years when they are needed. It is the sum of all water supply benefits for the 57-year period, divided by the number of years that such increased deliveries would be made.

Figure 8 also shows that the surcharge operation has an increasing benefit with increasing demand by consistently improving all three measures of increased delivery capability.

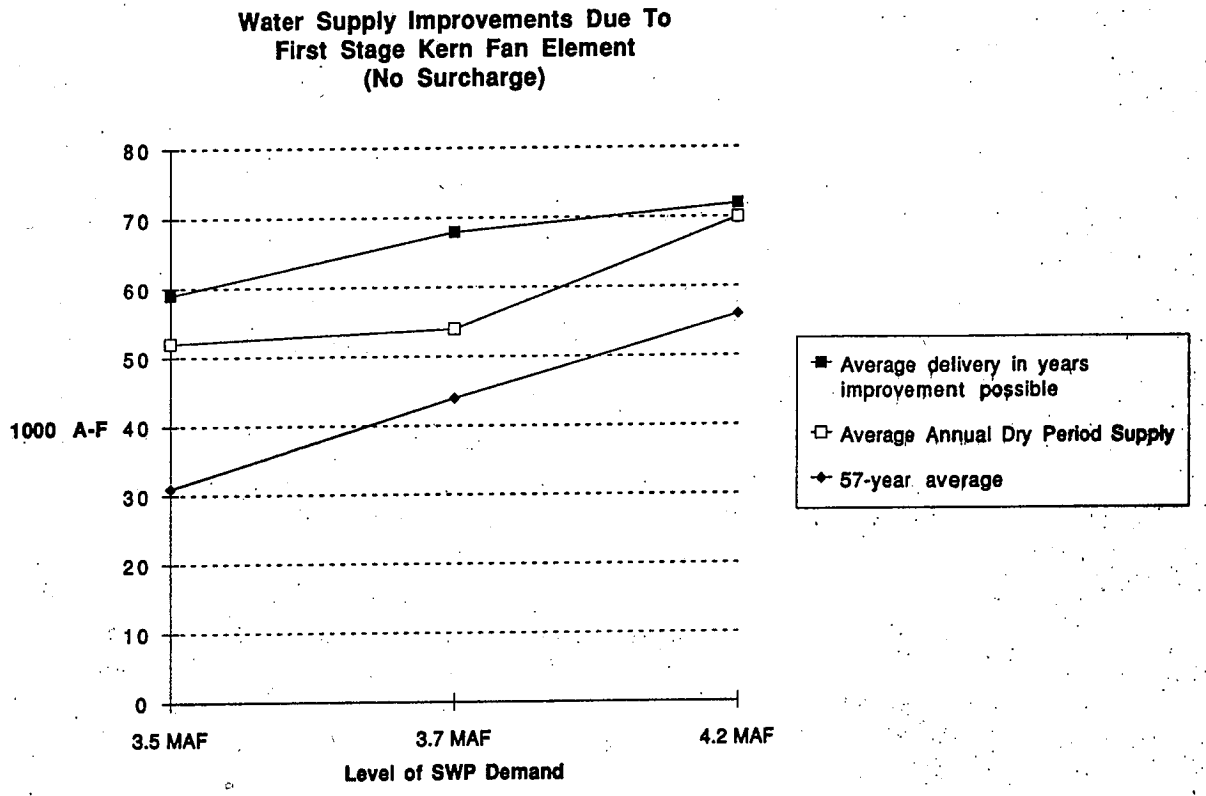
## Decreases in Project Deficiencies

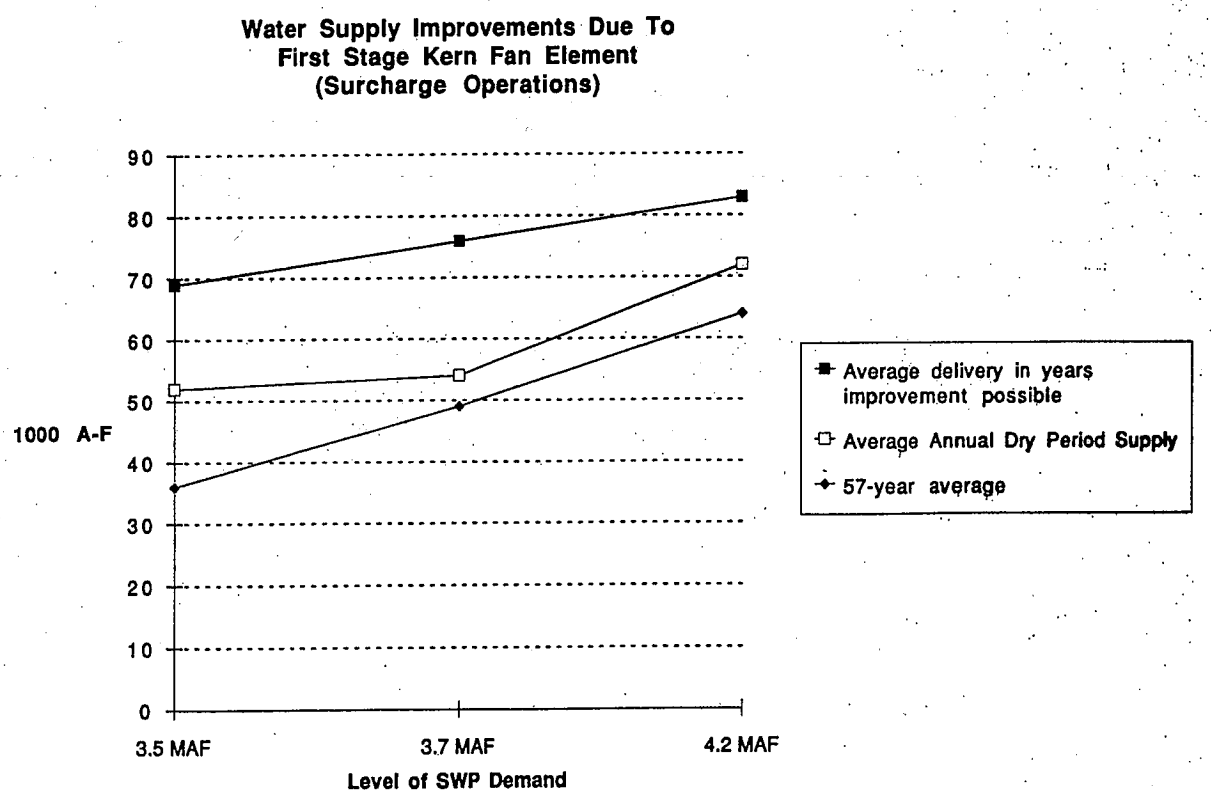
Figure 9 displays the probability distribution of deliveries associated with the Base Case condition, compared to the addition of the First Stage for the 3.5 MAF demand level. This figure indicates that the KFE would provide water supply benefits in the form of increased SWP deliveries over the full range of deliveries. This figure also shows that the First Stage would increase the probability of making full SWP deliveries from 47 percent to 49 percent.

As demands increase, the frequency of deliveries would be expected to decrease if limited new SWP facilities are brought on line. This is shown in Figure 10, which illustrates the probability distribution curves for both the 3.7-MAF and 4.2-MAF demand studies. A comparison of this figure with Figure 9 confirms the increased probability over time of not meeting full SWP demands. Note that at the maximum demand level of 4.2 MAF, the First Stage increases the probability of making full deliveries from 23 percent to 28 percent. Of course, this does not account for other potential SWP water supply additions being in place, such as the proposed Los Banos Grandes offstream storage reservoir.

# Figure 8 WATER SUPPLY IMPROVEMENTS

With and Without Surcharge



## Kern Fan Element Storage Fluctuations

Figure 11 shows the storage levels at the 3.5-MAF demand level in the KFE for the 1922–1978 period. This figure indicates that storage drops to zero only during the 1928–1934 dry period, which is a steady–state study requirement. During other periods, the storage stays close to full. Even during the 1976–1977 dry period, storage drops only 150 TAF. This is due to the extraction limit of 74 TAF per year, which allows the full storage to be withdrawn during the seven–year dry period but leaves water in storage during shorter drought periods. Of course, the remaining storage is factored into the WDRA, resulting in greater use of other SWP facilities (and higher deliveries) than would otherwise occur.

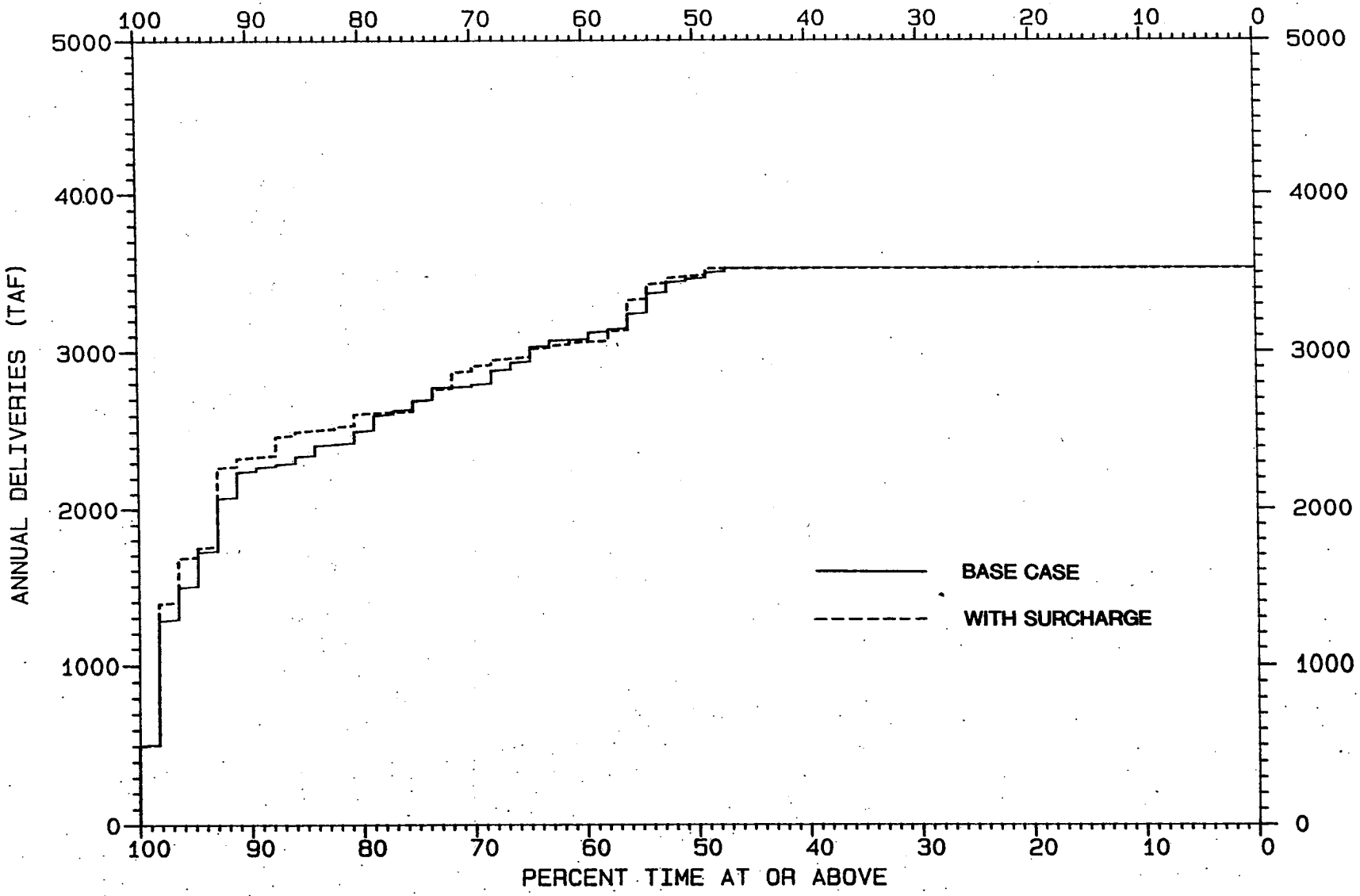
Figure 12 shows the same tracking of KFE storage for the 3.7-MAF and 4.2-MAF studies. The purpose of these figures is to indicate that the KFE storage is used more as SWP deliveries increase.

The maximum extraction rate could have been increased to withdraw additional water from storage during a very severe, short-term period such as 1976-1977. While the additional extraction capability would increase water supply accomplishments during this two-year period, it would not increase deliveries for other circumstances. The storage fluctuations do not directly reflect increases in individual years in SWP deliveries. This is because reliance on KFE ground water storage as a "bank account" of water allows SWP surface reservoirs to deliver additional water and operate at lower levels. It is this integrated operation that provides the full measure of water supply accomplishments from the KFE. While it is possible to develop and connect additional wells to the extraction system to withdraw more water for a 1976-1977 circumstance, the economics of leaving such facilities idle for long periods of time would need to be evaluated. It is possible that this concept will be examined in the future. Use of additional wells would need to be evaluated from the standpoint of fluctuations in ground water levels.

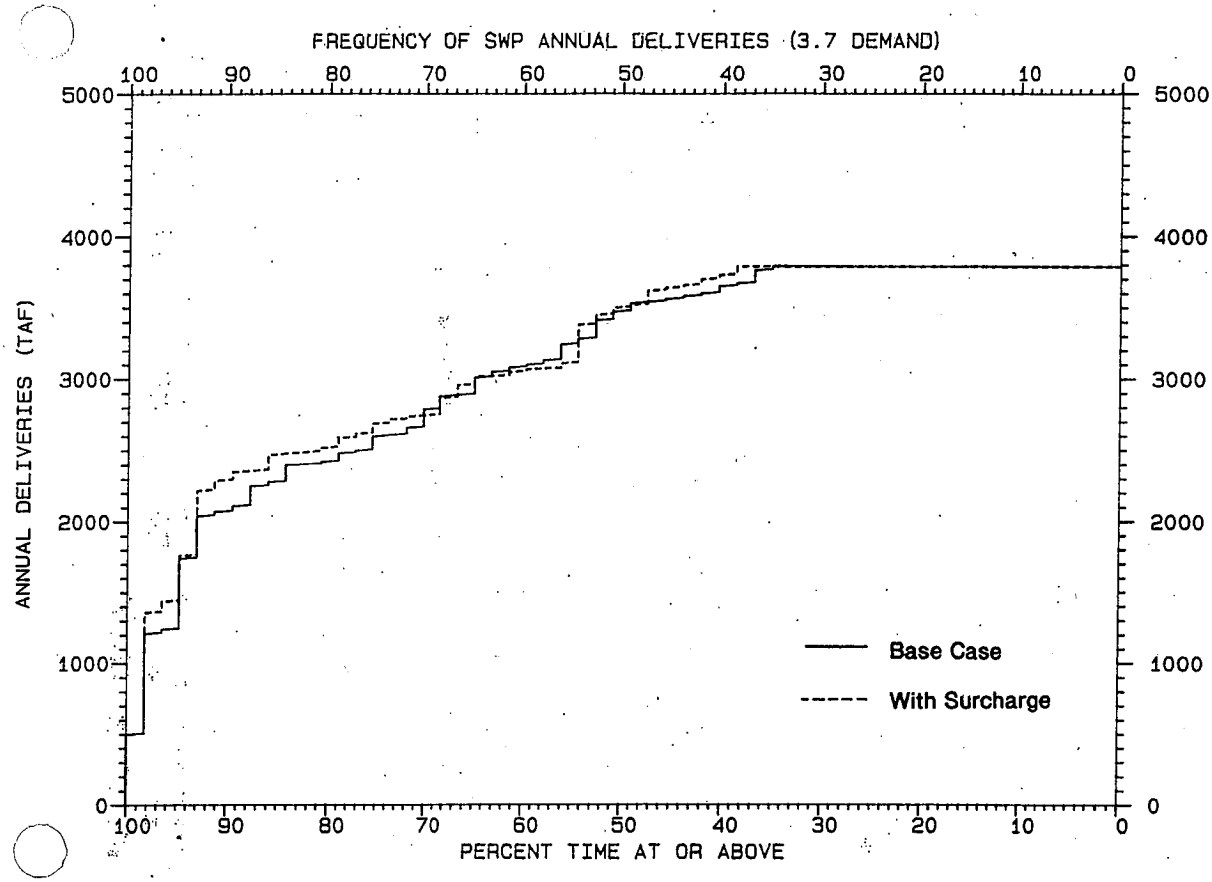
## State Water Project Operational Flexibility

The addition of the KFE adds to operational flexibility of the SWP by allowing reservoirs to be drawn down further to meet deliveries, thus providing greater capacity to store additional water during high flow periods. In addition, excess Delta flows in some winter months can be exported for KFE recharge when capacity is available at the SWP Banks Delta Pumping Plant. This is reflected in impacts of the First Stage on use of excess Delta flows, as well as impacts on Oroville Reservoir operations.

**Figure 9 FREQUENCY OF SWP ANNUAL DELIVERIES (3.5 MAF DEMAND)**



# Figure 10. FREQUENCY OF SWP ANNUAL DELIVERIES (3.7/4.2 MAF DEMAND)



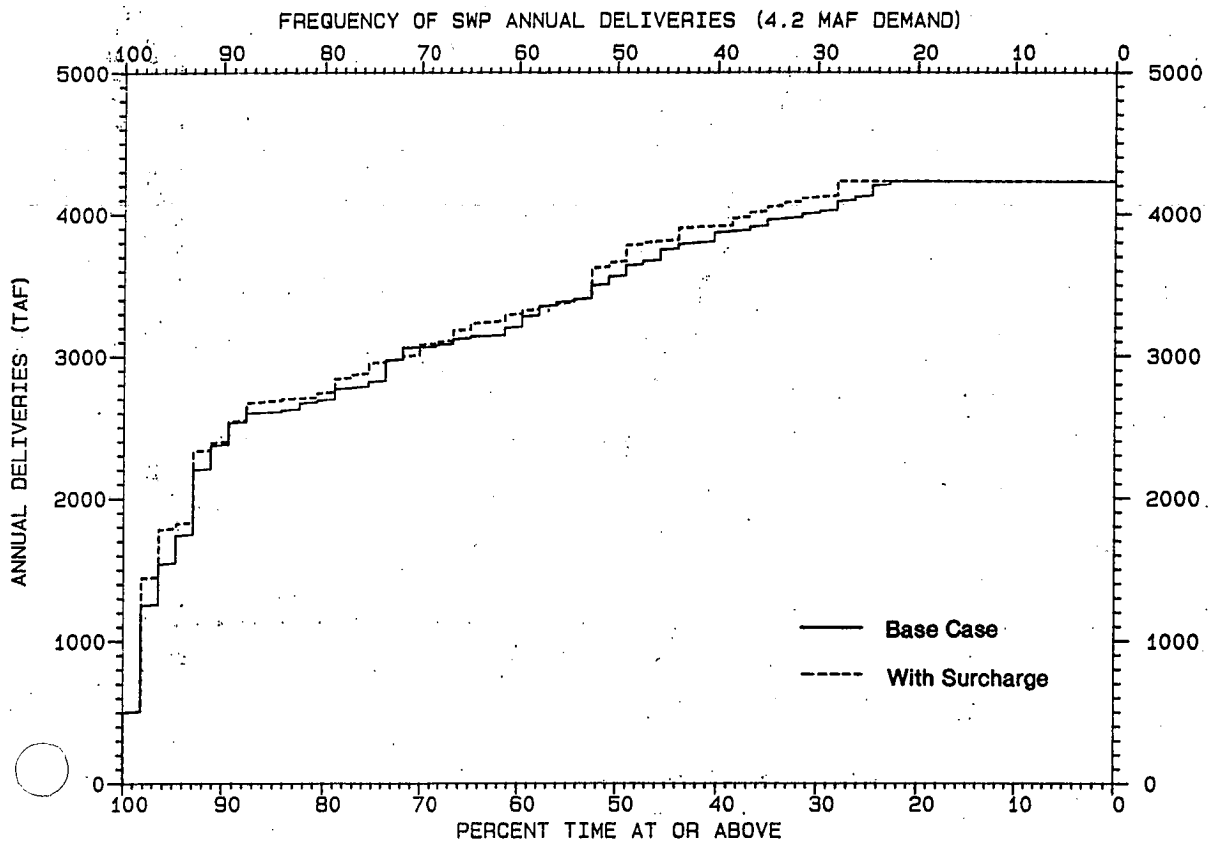
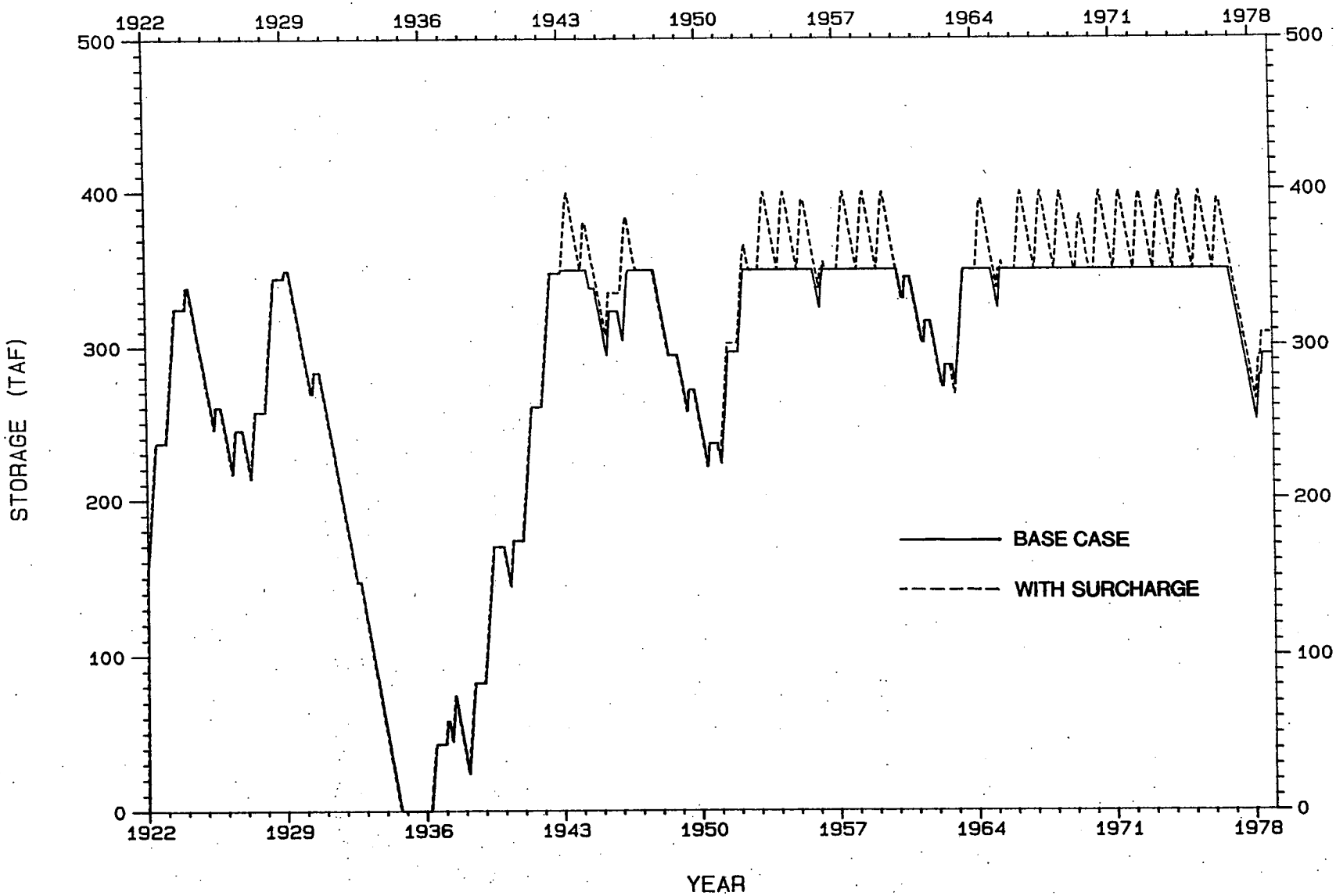
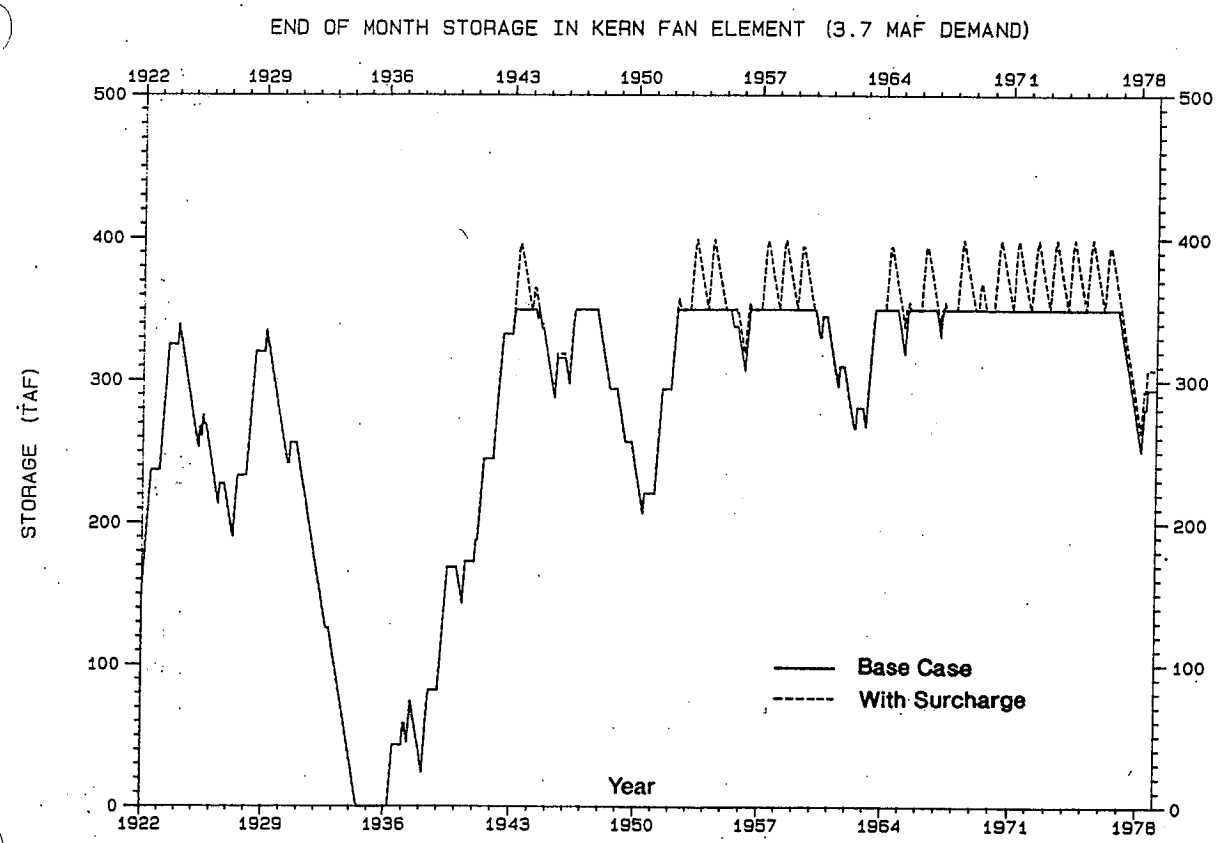
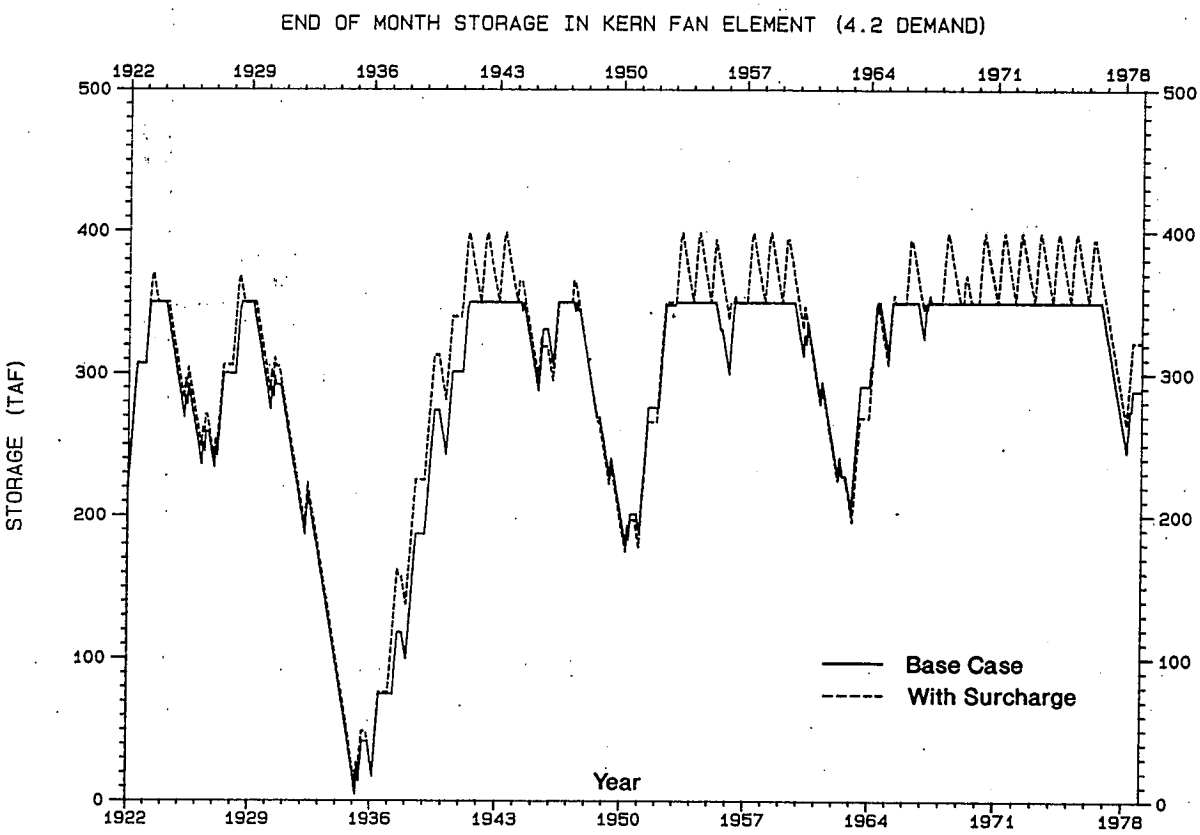



**Figure 11 END OF MONTH STORAGE IN THE KFE (3.5 MAF DEMAND)**



# Figure 12 END OF MONTH STORAGE IN THE KFE (3.7/4.2 MAF DEMAND)



All studies conducted to date indicate First Stage KFE storage drops below 100,000 acre–feet only at the end of the critical dry period, 1928–1934. After the initial fill, these studies show that at least 150,000 to 200,000 acre–feet is in storage all the time outside the critical dry period (Figures 11 and 12).

During the 1928–1934 critical period, the KFE is drawn to its lowest levels. It is also a period during which Oroville Reservoir storage falls or threatens to fall below the minimum power pool. However, due to the severity of the 1976-1977 drought, Oroville Reservoir falls below minimum power pool for all studies during 1977. The maximum annual KFE extraction of 75,000 AF limits total storage withdrawals during short-term severe droughts such as the two-year period, 1976–1977. Therefore, the KFE would still have 200,000 AF in storage at the end of 1977.

***Use of Excess Delta Flows.*** DWRSIM results were evaluated to determine impacts of capturing excess Delta outflows and the effects on the Delta carriage requirements over the 1922-to-1978 period. The quantity of excess water captured is similar to the quantity the First Stage can deliver on an annual average basis. The surcharge operation of the First Stage enables the SWP to capture a significant amount of Delta excess water in the 4.2 MAF study, since increased Delta pumping capacity was assumed. The results of the Delta carriage water requirements of the project indicate an increase in carriage water from the 3.5 MAF demand level study to the 3.7 MAF demand level study. In general, the quantities do not appear to be significant enough to affect the operation of the project. The surcharge operation appears to have some influence in decreasing the carriage requirements in the 3.5 MAF study. In the 4.2 MAF study, carriage water requirements decrease, due primarily to South Delta Improvements.

***Impact on Oroville Reservoir.*** Results of monthly storage in Oroville Reservoir showed an average decrease of 64,000 AF over the 1922–78 period at the 3.5 MAF level of demand. In the 3.7 MAF and 4.2 MAF results, the average decrease was slightly higher than in the 3.5 MAF studies. Lowest storage levels in Oroville Reservoir increased by 11,000 AF at the 3.5 MAF level of demand. At the 3.7 MAF level, lowest Oroville storage was the same. These lowest levels occurred in 1977 for both the Base Case and the With Project studies. At the 4.2 MAF level, lowest storage occurred in late 1977 and decreased by 63,000 AF, compared to the Base Case. These variations in results indicate that Oroville Reservoir operations during the 1977 dry period are very sensitive to general SWP system operations.

# POTENTIAL IMPACTS OF DIVERSIONS FROM THE SACRAMENTO-SAN JOAQUIN DELTA

Consideration has been given to potential impacts associated with the operation of the First Stage of the KFE on outflow from the Sacramento–San Joaquin Delta and associated impacts resulting from changes in export pumping.

## State Water Project Planning

Past SWP future water supply planning programs emphasized construction of additional surface reservoirs in areas upstream of the Delta. Since the early 1980s, DWR has gradually shifted its focus from upstream facilities to the development of offstream storage facilities south of the Delta. Such facilities, especially ground water projects, have the advantage of: (1) avoiding inundation of significant fisheries and/or recreation streams; (2) reducing flooding of sensitive wildlife habitat, particularly ground water recharge projects; (3) avoiding the difficulties of moving additional water through the Delta to the export pumps during environmentally sensitive times of the year; and (4) providing increased opportunity for filling storage capacity with high Delta winter flows.

As an offstream facility, KFE has the additional advantage that (other than intermittent use of 1,100 acres of recharge ponds) all storage will be underground.

## Impacts on Delta Outflow

The flow regime of the First Stage of the KFE involves recharge from November to April and year–round extraction. This six-month period coincides with the period of winter runoff and the availability of higher Delta outflows, as well as being outside the period of export pumping limits for fishery protection.

Water supply studies were done at the 3.5, 3.7, and 4.2 MAF levels of SWP delivery demands. Delta flow impacts will occur due to storage operations, when up to 15,000 AF per month (250 cfs) of water is diverted out of the Delta, conveyed through the California Aqueduct to Kern County, and spread in recharge basins. Impacts to Delta outflow will also occur as a result of re–operation of the State Water Project system in response to additional conservation storage. With the KFE, the SWP will be able to deliver additional water in many years, even under conditions when no water is pumped out of the KFE. The reason for this is that KFE storage will be accounted for in the SWP Risk Curve. Since surface storage can be refilled in most years, the Risk Curve sets a higher priority on use of surface storage than on the withdrawal of stored ground water. In part, this is due to the fact that the extraction rate, or "getaway capacity," of the KFE is only about 6,000 AF per month (100 cfs).

This operational mode is illustrated in Figure 11, which shows the year–to–year storage in the KFE account for a typical SWP operation study. This figure shows that for many years the KFE storage account is nearly full and is depleted substantially only during periods of prolonged drought. However, due to the effects of the Risk Curve, KFE benefits occur more frequently. Increases in SWP water deliveries due to the First Stage do not necessarily correspond to similar decreases in Delta outflow amounts in the same year, since a considerable portion of the addition-

al SWP deliveries is due to increased release and transfer of stored water from Oroville Reservoir. In addition, in some years following such storage transfer, Oroville Reservoir will be lower. Therefore, more water can be captured that would otherwise have contributed to Delta outflow during high-flow periods.

The KFE has the greatest opportunity to minimize adverse environmental impacts compared to potential surface water projects. In addition, potential conversion of some of the land from irrigated agriculture to native habitat will be beneficial to wildlife and will reduce overdraft in the Kern County ground water basin.

## Winter-Run Salmon Impacts

The winter run of Sacramento River chinook salmon has been listed as endangered by California and as threatened by the federal government. It is a unique race of salmon that spawns during the May-August period in the upper Sacramento River between Red Bluff and Keswick Dam. Spawning, incubation, and juvenile rearing take place during summer months when Sacrament River water temperatures are typically warm. Before the construction of Shasta Dam, the winter run spawned in the cool reaches of the McCloud River. In the 1950s and 1960s, reservoir operation created favorable winter-run habitat due to generally colder summertime temperatures in the upper Sacramento River. The spawning population of winter-run salmon increased to about 170,000 in 1969.

For the past several years, the run has been quite low. For example, in 1989 the winter run consisted of about 550 spawners. Many biologists believe that the dramatic decrease over the past 20 years has been due to the construction and operation of the Red Bluff Diversion Dam and an increase in spring/summer temperatures in the upper Sacramento River. The dam itself caused delays in migration of adults upstream and juveniles downstream. Delayed adult migration can result in less than optimum spawning, and a delay of downstream migrants leads to increased predation by squawfish and other fish. Some winter run spawned below the Red Bluff Diversion Dam in water that was too warm for good survival of the embryos. In addition, inadequate screens at the intake to the Tehama-Colusa Canal resulted in juvenile entrainment. Temperature problems were particularly severe in dry years when low reservoir levels caused water released from Shasta Dam to come from the warm-water layer near the reservoir surface.

Other factors that have been identified as adversely impacting winter-run populations include:

- Impacts of acid mine drainage that enters the upper Sacramento River immediately upstream of Keswick Dam. The drainage comes from the inactive Iron Mountain mine site in the Spring Creek watershed.
- Limited spawning gravels in the upper Sacramento River.
- Fish losses due to entrainment at the Glen-Colusa Irrigation District intake and other water diversion structures in the Sacramento River and the Sacramento-San Joaquin Delta.
- Commercial and sport harvest

The potential impacts of the First Stage of the KFE on winter-run salmon would occur during their passage through the Delta as downstream migrants. The time when winter-run outmigrants are in the Delta is not well defined, but DFG believes that peak abundance is in the January-through-March period. During the winter months, river flows are generally high, temperatures are

cold, the Delta Cross Channel gates are closed, and local agricultural diversions are minimal. Although this combination of factors should generally result in good through-Delta survival, there have been no studies specifically designed to estimate survival of winter-run smolts.

During dry, critical, and below-normal precipitation years, river flows are generally low, even during winter months. SWP and CVP pumping may cause some winter-run juveniles to be lost at the pumps. Although there is no definitive means of distinguishing a winter-run juvenile from one of the other three races of salmon present in the Central Valley system, DFG has developed a size/time relationship that may help differentiate the winter-run salmon from the other races.

The probability of entraining winter-run juveniles during critical, dry, and below-normal years increases as pumping increases during the January-through-March period.

As described earlier, the First Stage may result in additional Delta diversions during the November-to-April period. The exact monthly diversions specifically for the KFE are variable, but they can be up to 15,000 AF. At this time, it is not possible to quantify the losses of winter-run salmon smolts due to the increased diversion.

The possible adverse impact on winter-run salmon as a result of increased Delta diversions for the First Stage will in any event be very small. In 1990, the SWP diverted about 3.1 MAF of water from the Delta. Future SWP deliveries are projected to increase independently of KFE operations. The First Stage would add an average of 50,000 AF per year to the diversions. This would be an increase of less than 1.5 percent in total diversions.

By itself, the increase in diversions for the First Stage would not have a significant effect on winter-run salmon. The problem is that a variety of factors have pushed the winter-run salmon to endangered status. Efforts to restore them to a healthy, sustainable population address many factors, with emphasis on conditions in the upper Sacramento River where most of the problems occur.

As a result of a prelisting cooperative agreement, an interagency winter-run team was established to develop a recovery plan. This agreement was to implement actions to improve the status of winter-run chinook salmon. The cooperating agencies are the Department of Fish and Game (DFG), the U.S. Fish and Wildlife Service, the U.S. Bureau of Reclamation (USBR), and the National Marine Fisheries Service (NMFS).

The agreement contains the following intended actions:

- Open the gates on the Red Bluff Diversion Dam from December 1 through April 1
- Develop more effective water temperature control capability at the outlet from Shasta Dam
- Develop measures to control squawfish predation at Red Bluff Diversion Dam
- Correct Spring Creek pollution problem
- Restore spawning habitat between Redding and Keswick
- Correct salmon-related problems at Anderson-Cottonwood Irrigation District Diversion Dam
- Restrict in-river harvest of winter-run chinook salmon
- Develop a winter-run chinook salmon propagation program
- Modify the Keswick fish trap to prevent mortality to winter-run chinook salmon
- Continue and expand studies on winter-run chinook salmon
- Develop fish ladders as an alternative to raising the Red Bluff Diversion Dam gates

A joint federal/State recovery team has been established pursuant to the endangered species acts. The team, which differs from the one established by the cooperative agreement, is under the di-

rection of NMFS and includes DWR as a participant. In addition to the recovery team, DWR is in the process of initiating informal consultation with NMFS and DFG on the potential impacts of proposed Delta facilities and changes in south-of-the-Delta storage projects on winter-run salmon

If the recovery team and the consultation process result in a finding that SWP pumping causes a taking so that an incidental take permit is required under the State or federal Endangered Species Acts, DWR will work to provide appropriate mitigation and offsetting measures. Measures being considered are:

- Participation in upstream measures that are critical to survival of the winter run. Examples include gravel restoration (such as now under way as part of the Delta Pumping Plant Agreement), construction and operation of a winter-run hatchery, and flow and temperature control accomplished through the Coordinated Operations Agreement
- Work with USBR to control diversion of winter-run smolts from the Sacramento River through operation of the Delta Cross Channel
- Work with DFG and other agencies to reduce losses at the SWP Banks Delta Pumping Plant intake by increasing screen efficiency and reducing losses to predators in Clifton Court Forebay.

The existing DWR/DFG agreement (described below) to mitigate the direct effects of SWP Delta pumping also established a program funded to benefit all races of chinook salmon in the Sacramento-San Joaquin system.

## 1986 Delta Pumping Plant Agreement

The primary impacts with additional Delta diversions associated with the First Stage will be direct fish losses at the Harvey O. Banks Delta Pumping Plant (Delta Pumping Plant). On December 30, 1986, the Directors of Water Resources and Fish and Game signed an agreement (Fish Agreement) to protect Delta fish populations by offsetting direct losses of fish at the Delta Pumping Plant. While many of the fish diverted are saved by fish screens at the pumping plant and returned to the Delta, others are lost due to predation, poor screening efficiency for small fish, and handling in the salvage process. These losses, called direct losses, occur from the time fish are drawn into Clifton Court Forebay until the surviving fish are returned to the Delta.

The Fish Agreement negotiations were aided by an advisory group consisting of representatives from United Anglers, Pacific Coast Federation of Commercial Fishermens' Associations, Inc., Planning and Conservation League, and the State Water Contractors. The agreement establishes a procedure for calculating direct losses on an annual basis and requires DWR to pay for mitigation projects that would compensate or offset such losses. In addition, DWR has provided $15 million to initiate a program to aid in the recovery of currently depressed fish populations.

Operation of the First Stage of the KFE is expected to result in minor increases in direct and indirect impacts to Delta fisheries. These impacts will result from additional diversions at the Delta during the period November – April, as well as the additional diversions and deliveries to SWP water users resulting from maintaining (and eventually withdrawing) this additional amount of SWP conservation storage.

Direct Delta impacts associated with First Stage operations will be handled by the existing December 30, 1986 agreement, which addresses Delta diversions with existing Delta Pumping Plant limitations imposed by the U.S. Army Corps of Engineers, and SWP contractual commitments for water deliveries. The First Stage is feasible and can be fully operated without additional pumping capacity.

Pursuant to Article VII of the Fish Agreement, DWR and DFG have commenced negotiations on further agreements which will address fishery impacts not considered in the December 30, 1986 agreement. These impacts include indirect effects from existing SWP operations and future additions to SWP facilities (including the First Stage of the KFE). USBR has joined in these negotiations, and the indirect impacts of the CVP are also being addressed.

If the Article VII negotiations have not been completed by the time recharge activities are scheduled to begin at KFE, DWR will establish a mitigation program that will implement some of the following provisions:

- Continue support for studies on the effect of temperature and flows and how project operations might be improved to benefit fish and wildlife.
- Install temporary barriers and monitor benefits to fish and wildlife.
- Support increased State federal funding for mitigation studies and projects.
- Support the feasibility of installing fish screens on other large Delta diversions.

A "Framework of Process to Address Fish and Wildlife Impacts of the State Water Project and Central Valley Project in the Sacramento-San Joaquin Estuary" was signed by DWR, USBR, and DFG in October 1990. This framework agreement forms the basis for subsequent agreement(s) that will cover the indirect impacts of both the SWP and CVP in the estuary.

## WATER QUALITY

This section provides a discussion of the known and potential surface and ground water quality concerns on the KFE property.

### Recharge Water Quality

The water that will be used for recharge, SWP and/or Kern River water, is generally of excellent mineral quality. It is also expected to be of good quality with respect to organic contaminants, although only limited historic data is available. Kern River water is a low total dissolved solids (TDS), sodium–calcium bicarbonate type water. The average TDS is about 90 milligrams per liter (mg/L) and ranges from about 50 to 190 mg/L. Water from the California Aqueduct averages about 250 mg/L TDS, with levels seldom falling below 150 mg/L and very rarely exceeding 500 mg/L.

Use of low TDS Kern River water for recharge may be detrimental on soils containing significant amounts of clay because of the tendency to cause deflocculation and thereby reduce permeabilities. At times Kern River and SWP water contain a high percentage of sodium which could also result in development of permeability problems on sensitive soils. In addition, during periods of local inflow to the California Aqueduct suspended solids content is sufficiently high to require cessation of recharge.

Water quality criteria for recharge will be established to guide project operation. Criteria will be established for the following parameters: (1) electrical conductivity as a measure of TDS; (2) sodium content; (3) total suspended solids; (4) turbidity; (5) organic constituents; and (6) nutrients. A start toward developing criteria are the TDS goals proposed in the agreement being negotiated for use of the City of Bakersfield's 2800–Acre Recharge Area. The proposed criteria limit TDS to 500 mg/L instantaneous, 440 mg/L as a 30–day average, and 300 mg/L as an annual average. These requirements can be met most of the time other than dry and critical years (when little recharge of SWP water would be expected to occur).

## Salt Balance

The Kern County Ground Water Basin is essentially a closed hydrologic system and, as such, is experiencing an adverse salt balance. Each year salts dissolved in surface water deliveries from the Kern River, the California Aqueduct, and the Friant–Kern Canal arrive in the basin. Essentially, no salts leave. It is desirable to operate the KFE in a manner that does not significantly worsen the basin's adverse salt balance.

Mineral quality of ground water varies considerably (TDS ranging from about 100 mg/L to 4,000 mg/L and averaging 280 mg/L) in the project area. The average TDS of SWP water for recharge is expected to be about 203 mg/L, based on review of measured California Aqueduct water quality from January 1980 through December 1989 for wet and above–normal Sacramento River Index years. The wells selected for First Stage operations currently have an average TDS of 174 mg/L. This is lower than the 280–mg/L average TDS of KFE ground water for two reasons. First, extraction facilities selected for First Stage use are concentrated near proposed KFE recharge facilities and the City's 2,800–Acre Recharge Area — both areas of good water quality. Second, extraction during First Stage operations will intentionally avoid areas of poor ground water quality along the western edge of the KFE property because of the potential that pumpage there could create high gradients that might induce migration of poor quality water from the west.

Operation studies conducted to date indicate a total of 1,356,000 AF will be delivered to the KFE over the 57–year study period. Assuming that SWP recharge has an average TDS of 203 mg/L, this will add 374,100 tons of salt to the ground water basin.

During extraction, all water recharged will eventually be withdrawn after reduction for losses. Based on preliminary loss estimates used for operation studies, 1,308,540 AF will be extracted. During the First Stage, an estimated 1,029,821 AF (79 percent) of the extractions will be exchanged locally and will remain in the Kern County Ground Water Basin. For that portion of extracted water that is exchanged, the export of salts from the Kern County Ground Water Basin will be that contained in SWP deliveries that would have been made in the absence of KFE extraction exchanges. The salinity of foregone SWP deliveries in KFE extraction years is estimated to be 319 mg/L, based on analysis of 1980–through–1989 California Aqueduct salinity during typical extraction years. The remaining 278,779 AF (21 percent) of KFE extractions that would be delivered directly to the California Aqueduct are assumed to have an average salinity of 174 mg/l. The total amount of salts removed during extraction operations, both directly and by exchange, is therefore estimated to be 512,353 tons. The net positive salt balance of the First Stage is 138,266 tons (512,353 tons less 374,100 tons). This net positive balance is likely to be greater, due to conservative assumptions regarding both recharge and extraction water quality.

Project recharge facilities will also be made available in high-flow years to recharge low-TDS Kern River water that would otherwise pass into the California Aqueduct through the Kern River Intertie. Prior to the KFE land purchase, there were high diversions of water onto the Tenneco lands. Recharge of flood waters is expected to be higher with the First Stage for two reasons. First, much of the water diverted by Tenneco was used directly for irrigation, offsetting ground water overdraft that otherwise would have occurred. Since the First Stage will have no irrigation, this factor increases the net recharge that would occur. Second, diversions of flood flows onto KFE lands are expected to be higher than if Tenneco had continued its ownership since there will be no crop lands to damage and since it is assumed that Tenneco historically diverted as much as possible. Such factors further support a projection of positive salt balance for operation of the First Stage.

Another consideration affecting the salt balance is the potential for leaching soluble salts now concentrated in soils above the water table. To evaluate the potential for mobilization of the salts in the vadose zone, DWR collected shallow, 50-foot soil samples to analyze for soluble salts. With irrigated agriculture being phased out, vadose zone soluble salts would remain immobilized unless flushed by percolation from recharge ponds (either First Stage or local flood flow recharge) or by water levels rising above current levels. Analysis of the soil samples indicates that only low levels of soluble salts are present in the vadose zone and that they do not represent a significant threat of salt loading to the ground water, should they be partially mobilized.

In the long term, present farming operations would have been imbalanced with respect to water supplies. From 1975 through 1985, a disproportionate amount of surface water was available, compared to the long-term conditions of the Kern River. Consequently, the KFE lands would have been in long-term overdraft. This is widely recognized, and it formed the basis for the provision in the 1987 MOU that phase-out of irrigation will contribute to ground water overdraft reduction. Phase-out of these irrigated lands also will reduce the concentration of salts from farming activities on KFE lands and thereby slow the Kern County Ground Water Basin salt buildup.

## Ground Water Quality

Ground water samples from many of the production and monitoring wells on the KFE property have been collected and analyzed. The location of the wells sampled is shown in Figure 13. Analyses were performed for standard minerals and minor elements, volatile organics, selected pesticides, and radiological parameters. In addition, 57 shallow (50-foot) soil borings were drilled throughout the property to analyze for selected pesticides. No detectable residues (EDB, DBCP, Aldicarb, aldicarb sulfoxide, or aldicarb sulfone) were present in the soil samples. Hand auger samples were collected in areas with recognizable hydrocarbon contamination in the surface soil. In addition, 39 test holes are being drilled in the proposed First Stage recharge ponds. They are being sampled for those pesticides that were used in the area and have a significant probability of leaching to the ground water. Results from about one-third of these holes were available at the time this EIR was being prepared. No pesticide residues were detected.

Drinking water standards have been used as an indicator of the suitability of ground water for use as a municipal and industrial supply. The drinking water standards were established by the U.S Environmental Protection Agency and the California Department of Health Services. The Maximum Contaminant Levels (MCL) (Primary Standards) are established at levels that minimize the

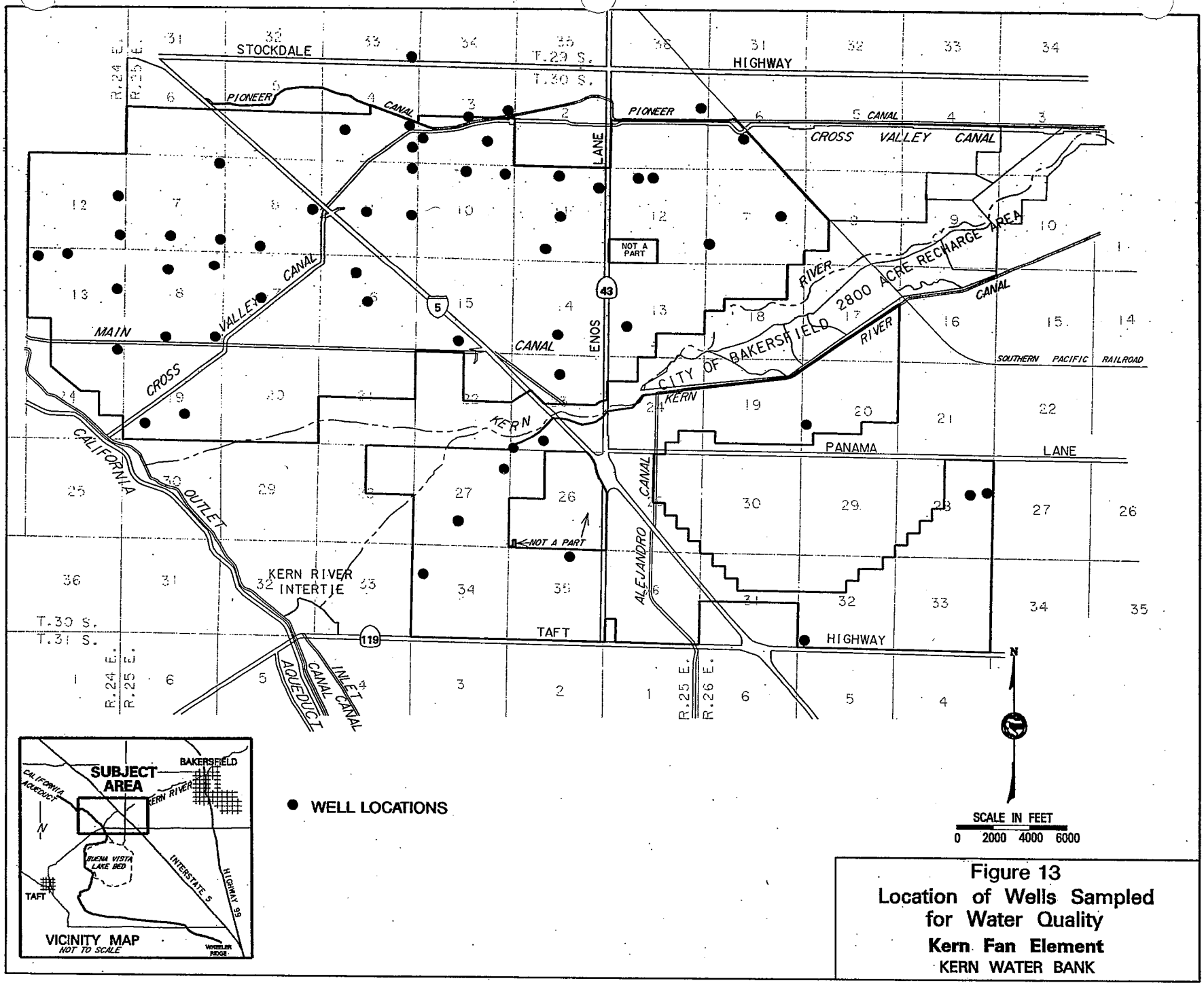



Figure 13
Location of Wells Sampled for Water Quality
**Kern Fan Element**
KERN WATER BANK

adverse health effects of specific chemicals and are mandatory requirements for public water supply systems. Secondary standards are established for aesthetic effects and are not mandatory requirements. The Department of Health Services is required to establish recommended public health levels (RPHL) for contaminants. RPHLs, when established, will be as stringent or more so than MCLs. As RPHLs are established, DWR will consult with the SWP contractors on the desirability of using them to guide projects.

The general mineral quality of the ground water in the project area is good. The TDS concentrations of ground water are usually less than 500 mg/L. The TDS concentrations in a small area north of the Kern River Bypass channel near Tupman approach 4,000 mg/L. However, this area appears to be relatively isolated from the main aquifer system. One monitoring well in Section 12, T30S, R25E, located one-eighth-mile down-gradient from sumps used for brine disposal, has EC values of about 7,500 micromhos per centimeter (μhos/cm) in the shallow zone, 3,800 μhos/cm in the middle zone, and 1,500 μhos/cm in the deep zone.

A few wells exceed the recommended drinking water criteria of 250 mg/l for sulfate and chloride. However, the blend of water that returns to a source of public supply (California Aqueduct or CVC) is not expected to exceed these criteria. Elevated levels of nitrate occur in a band across the northern portion of the project area. The elevated nitrate is believed to result from leaching nitrogen-bearing fertilizers during irrigation. Outside this area nitrate levels are uniformly low.

The band of elevated nitrate corresponds to areas that have been in irrigated agriculture since the 1950s and in wells that tend to be perforated at relatively shallow depths. Other parts of the property have only been irrigated since the mid-1970s or have never been irrigated. Wells in these areas are generally perforated at a greater initial depth than those with elevated nitrate. While there are currently low nitrate levels in these areas, it is possible that increasing levels in produced water may occur during project operation as water levels decline. However, levels will probably not increase beyond those levels found in the elevated band and, therefore, should not interfere with project operations.

Five wells exceed boron levels of 0.2 mg/L and would be detrimental to sensitive plants if used for irrigation. The highest concentration (0.6 mg/L) occurs in two wells located near Tupman, outside the high TDS region. The level of boron in these five wells is not expected to affect the project's ability to produce a blended water supply with low boron levels.

In two areas the concentration of arsenic exceeds the drinking water MCL of 0.05 mg/L, and in one monitoring well barium exceeds the MCL in the shallow zone. Water extracted from these areas will require blending to decrease contaminant levels to concentrations before returning to a public water supply source.

## Known Ground Water Quality Problems

During feasibility study investigations for the KFE, several ground water quality problems were identified. In general, First Stage KFE facilities have been located to avoid these problem areas. The contaminants identified are discussed below:

***Ethylene Dibromide.*** EDB is a nematicides that was banned in 1983. Before 1983, EDB was applied over fairly large areas of the KFE property. Low levels of EDB were detected in the

north central portion of the project area illustrated in Figure 14. The levels found exceeded the drinking water MCL of 0.02 microgram per liter (μg/L). Although data are inadequate to confirm this, the contaminated water in this area may be continuous with a large area of contaminated water in the Rosedale–Rio Bravo Water Storage District to the north. The boundaries of the area containing EDB cannot be accurately delineated, except to the west where it is fairly well defined by wells containing uncontaminated water.

Under present conditions, the contaminated water will slowly move downgradient to the north or northwest and be flushed from the project area. In addition, the present use of water in this area for agriculture will remove some of the EDB, but it will not have a significant impact in the time remaining before irrigated agriculture on the property ceases. Neither of these activities will eliminate the problem in the near term.

Ground water is thought to be stratified in this area. Based on this stratification, it is believed that water containing detectable levels of EDB are restricted to about the upper 250 feet of the aquifer system. In this situation, the potential for contamination of deeper zones is of concern. During the irrigation season, vertical gradients are created in the area that may permit movement of contaminated water downward through well bores. However, water levels largely equilibrate when pumping stresses are eliminated, greatly reducing the potential for water movement along this pathway. Furthermore, water moving into deeper zones through the wells will largely be extracted when the next irrigation season commences. Therefore, under existing conditions, the threat of deep contamination does not appear to be significant. However, if future extraction wells are perforated in deep zones, the potential for EDB contamination in the deeper part of the aquifer system would increase. Conversely, wells pumping from the shallower part of the aquifer would accelerate the removal of contaminated water.

While EDB has been applied on several parts of the KFE property, detectable levels in ground water have been found in only a limited portion of the area. Wells with detectable levels of EDB are older, poorly constructed wells that are perforated at relatively shallow levels and will produce water from near the water table where the highest levels of EDB would be expected. In the other areas where EDB has been used, most, but not all, wells were installed more recently and are not perforated above a depth of 250 feet. Due to the stratified nature of the aquifer system, samples withdrawn from these wells may not adequately represent the water most likely to be contaminated. The potential exists for the detection of expanded or new areas of contamination as water levels decline during project operation.

It is not expected that water contaminated with EDB will be extracted during First Stage operations. However, if contamination is detected in extracted water and if the MCL for drinking water is to be met, water containing EDB may require treatment before it is delivered to the California Aqueduct or the CVC, both of which are sources of public water supply. This would not apply to the CVC during times in which water is not being delivered to domestic users. EDB is volatile and treatment by air-stripping is possible. However, the low levels present and high removal efficiencies required would complicate the design of a treatment system. Transport in an open conveyance system would probably not result in sufficient removal to meet the MCL. Additional investigation is required to define the extent of contamination and to evaluate the feasibility of treatment options.

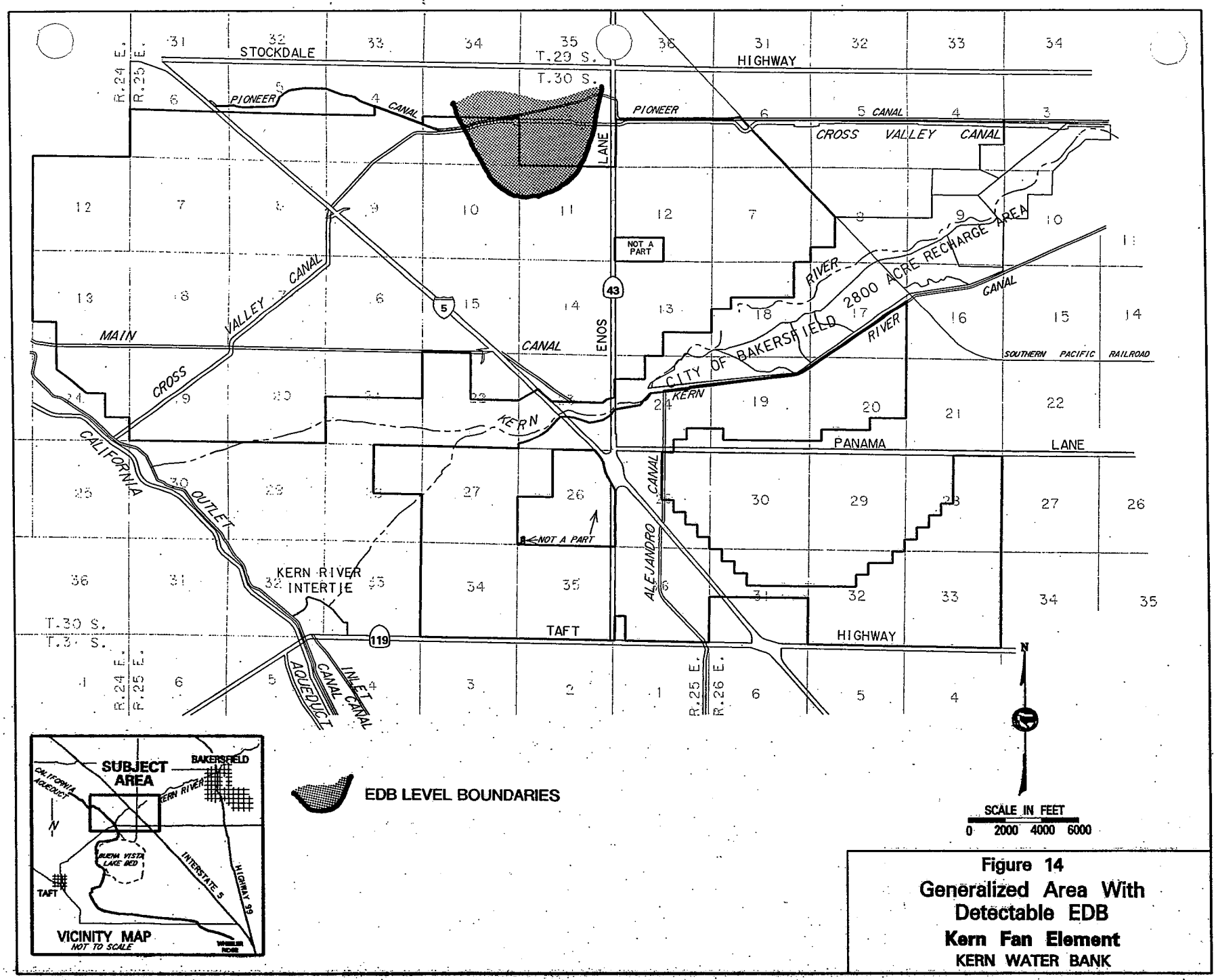



**Figure 14**
**Generalized Area With Detectable EDB**
**Kern Fan Element**
**KERN WATER BANK**

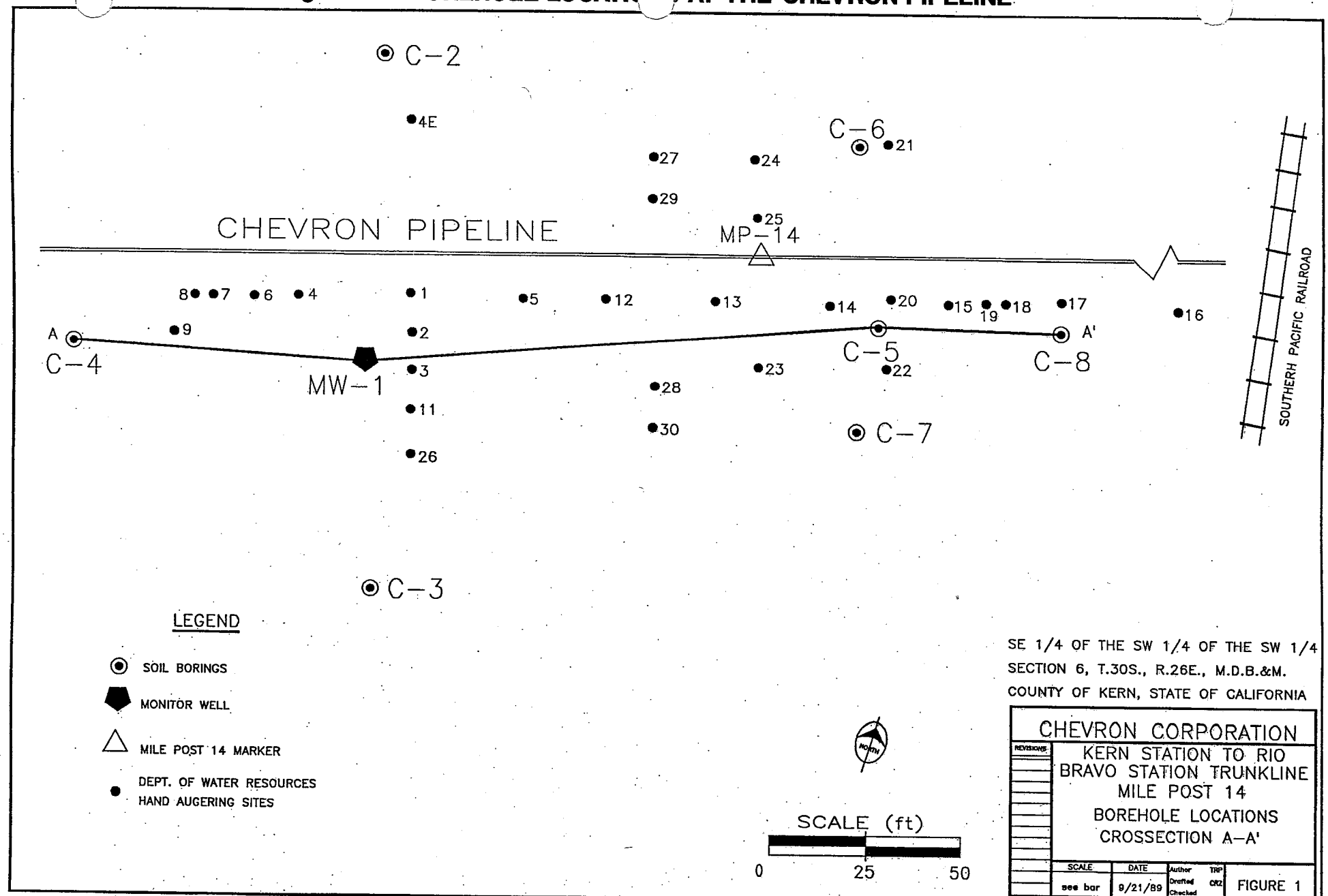
***Toxaphene.*** Toxaphene, an insecticide commonly used on crop types that occur on the KFE, has been tentatively identified at a level of 9 μg/L in well 30/25-19Kl. The MCL for toxaphene is 5 μg/L. Toxaphene is not particularly mobile in the soil environment, but it does have some potential for reaching ground water through normal agricultural use. Contamination, if verified, could possibly have resulted from direct contamination of the well from nearby uses or through normal agricultural applications. No information exists to allow a choice between these alternatives. This well will be resampled periodically while agricultural use continues in this area. If the concentration declines this would suggest local contamination at the well site and greatly lessen concern about the possible extent of contamination.

***Eptam (EPTC).*** Eptam has been identified in samples from well 30/25-8Pl at a level of 170 μg/L. At present, no action level or MCL exists for Eptam. There is no reported use of Eptam on KFE property. Eptam is a herbicide that is commonly applied in irrigation water. It is not highly mobile but has occasionally been reported as a ground water contaminant. Inspection of well 30/25-8Pl indicated that a functioning backflow prevention device was not present. This suggests that contamination resulted from movement of water containing Eptam into the well bore, resulting in very localized contamination. This is supported by the relatively high level of contamination found. However, more widespread contamination from applied Eptam cannot be ruled out at present. As with Toxaphene, this well will be sampled periodically to ascertain whether cleanup occurs through continued use.

***Diuron.*** Preliminary sampling and analysis indicates that the herbicide Diuron is present at a concentration of 0.26 μg/L in the upper zone of monitoring well 30/26-19B. This zone is perforated at a depth of 120 to 220 feet and water levels were at a depth of about 90 feet at the time of sampling. At present, no action level or MCL exists for Diuron. Diuron has been used nearby for weed control and is relatively mobile in the soil environment. It has also been commonly found as a ground water contaminant in other areas. The extent of contamination cannot be determined with present information.

***Petroleum Hydrocarbons.*** During routine shallow exploration of potential recharge pond sites, petroleum hydrocarbon contamination was detected along a pipeline owned by Chevron Pipeline Company in Section 6 of T30S, R26E. DWR made 30 hand borings at the site to define the extent of shallow soil contamination. In addition, Chevron drilled nine hollow-stem auger borings and collected split-spoon samples for hydrocarbon analysis. Chevron completed one of the auger holes as a monitoring well with a depth of 120 feet. The locations of the various borings are shown in Figure 15. This exploration resulted in the delineation of an area of contamination about 175 feet along the pipeline, with a maximum width of about 120 feet, and a maximum depth of about 65 feet (Figure 16). Selected soil samples were analyzed for total petroleum hydrocarbons by EPA Method 418.1. The greatest concentration, 12,200 milligrams per kilogram, was found at a depth of 20 feet at the monitoring well site. The results of analyses by EPA Method 418.1 indicate the extent of contamination by relatively immobile hydrocarbon fractions. However, the more mobile volatile fractions are lost during the extraction process used in this procedure. Initial sampling of the monitoring well indicated that benzene was present in the ground water at a level of 10.6 μg/L, significantly exceeding the MCL of 1 μg/L. Upon resampling, after a period of about two months, the level of benzene found was slightly below the MCL, and low levels of

## Figure 15 BOREHOLE LOCATIONS AT THE CHEVRON PIPELINE

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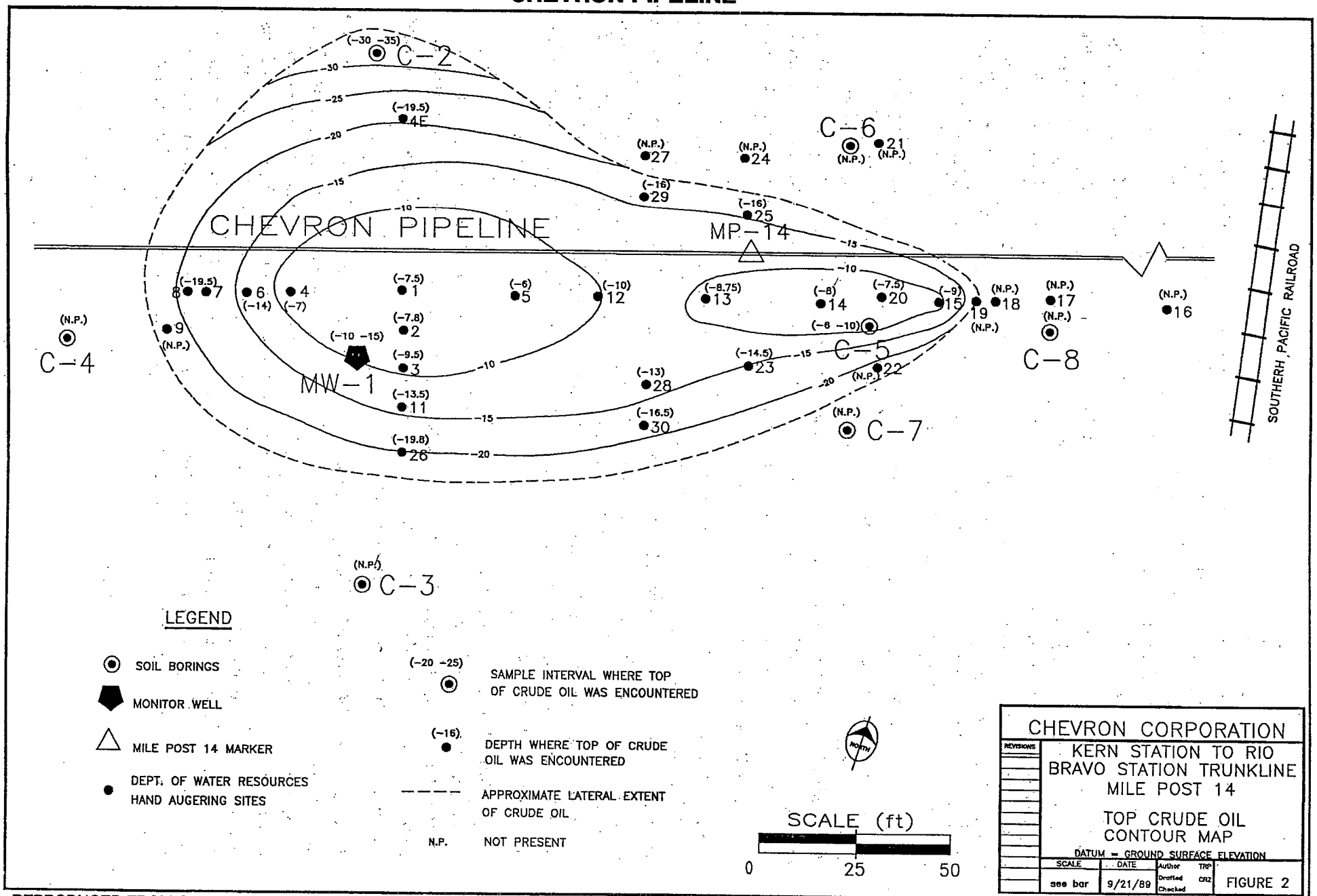
# Figure 16 TOP OF CRUDE OIL CONTOUR MAP
## CHEVRON PIPELINE

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toluene, ethylbenzene, and xylene were detected at levels below their respective MCLs. Chevron, at DWR's request, conducted additional sampling and installed five more monitoring wells to further define the extent of contamination. The results of this work are not yet available. This effort is being coordinated with the Regional Water Quality Control Board.

Concern at this site focuses on the potential extent of ground water contamination that could limit use of extracted water or require treatment before delivery into the CVC or California Aqueduct. Recharge has not occurred at this site for about three years. This suggests that a significant area may contain contaminated ground water and that the low levels of benzene, toluene, and xylene found in the monitoring wells, which are upgradient of the pipeline, may not be representative. This site is in one of the prime potential recharge areas on the KFE property, and unremediated soil contamination will restrict the extent to which water levels can be allowed to rise in response to recharge without risking the mobilization of hydrocarbons in the unsaturated zone.

As a follow-up to the discovery of contamination, DWR constructed shallow hand auger borings at intervals of 500 feet along this pipeline alignment (similar work will be done along other pipelines), and identified other areas of soil contamination, two of which show evidence of fresh hydrocarbons in the soil and several areas with weathered hydrocarbons (Figure 17). Chevron Pipeline Company submitted a proposal for staged investigation of these sites to the Regional Board. During the First Stage, the extent of shallow (to 20 feet) contamination will be investigated at each site, with additional exploration and monitoring to be developed, if needed.

***Arsenic.*** Two areas on the KFE property contain arsenic exceeding the MCL of 0.05 mg/L (Figure 18). The southernmost area along Taft Highway is on the northern fringes of a regional area of arsenic contamination that probably extends eastward and westward along the southern boundary of the project area. This area has not been adequately sampled. The arsenic is thought to be naturally occurring in the aquifer, although there could be some contribution from arsenical pesticides and defoliants. The presence of arsenic is not expected to be a significant impediment to project operation because levels are expected to be diluted to below the MCL of 0.05 mg/L before delivery into the California Aqueduct.

***Gross Alpha/Uranium.*** Two areas contain ground water that slightly exceeds the MCL of 20 picocuries per liter for uranium. Uranium is commonly found (as a natural component) in ground water in the San Joaquin Valley. The low levels found in the project area can be readily diluted to below the MCL before the water is returned to a source of public water supply and do not create a significant impediment to project operation.

***Excessive Total Dissolved Solids.*** Figure 19 shows the generalized areas within the KFE with TDS greater than 500 mg/L. The high TDS area near Tupman is not expected to represent a significant problem because neither recharge nor extraction will occur here. The possibility of movement of this water during project operation will be monitored. The area of high TDS near the Enos Lane Test Ponds is more of a problem because it is in the best potential recharge area for the KFE. It has not been characterized for parameters of concern other than TDS and standard minerals, and the areal extent of high TDS water is unknown. The dimensions and character of the plume must be fully characterized before either recharge or extraction activities are conducted in the area.

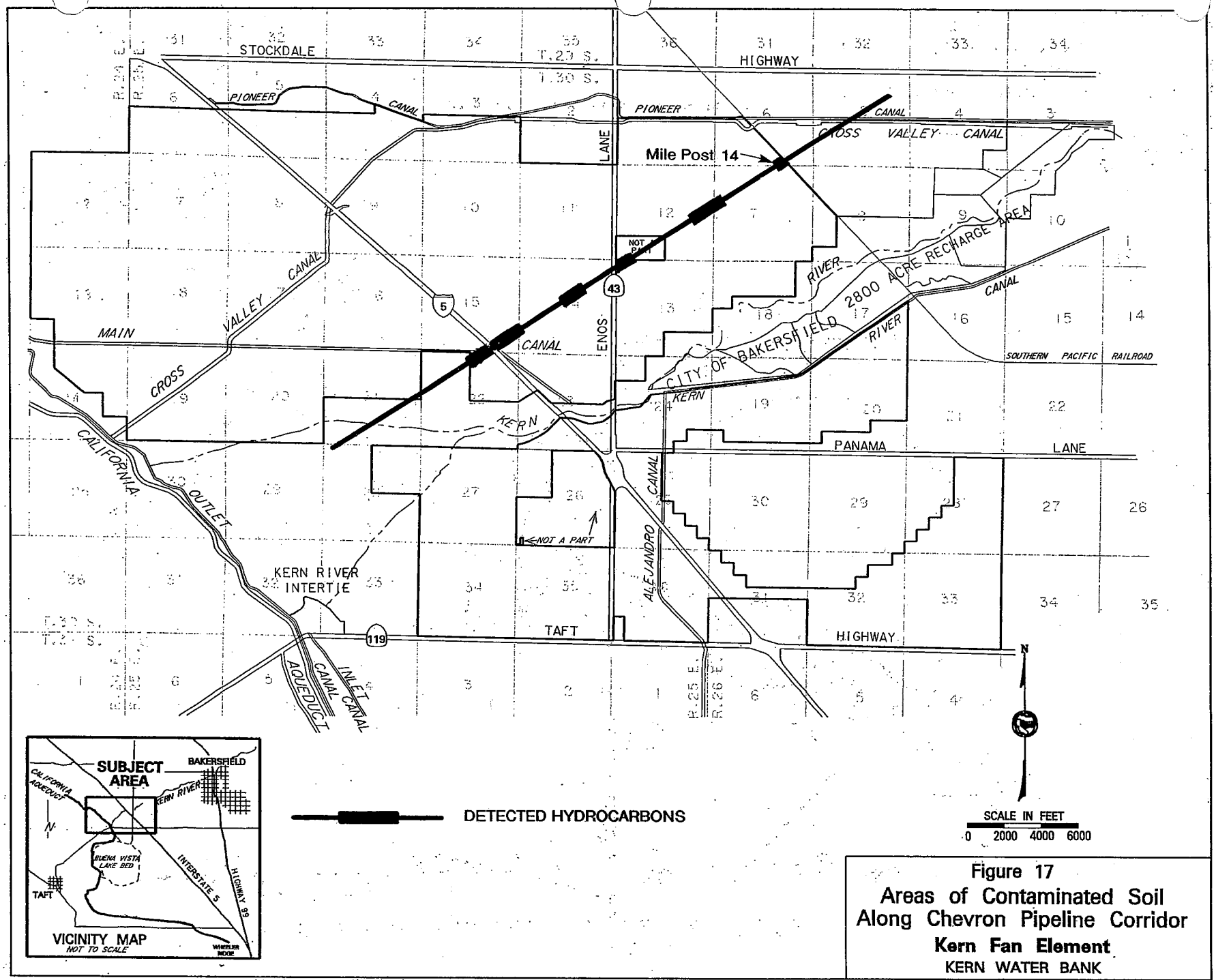



Figure 17
Areas of Contaminated Soil
Along Chevron Pipeline Corridor
**Kern Fan Element**
KERN WATER BANK

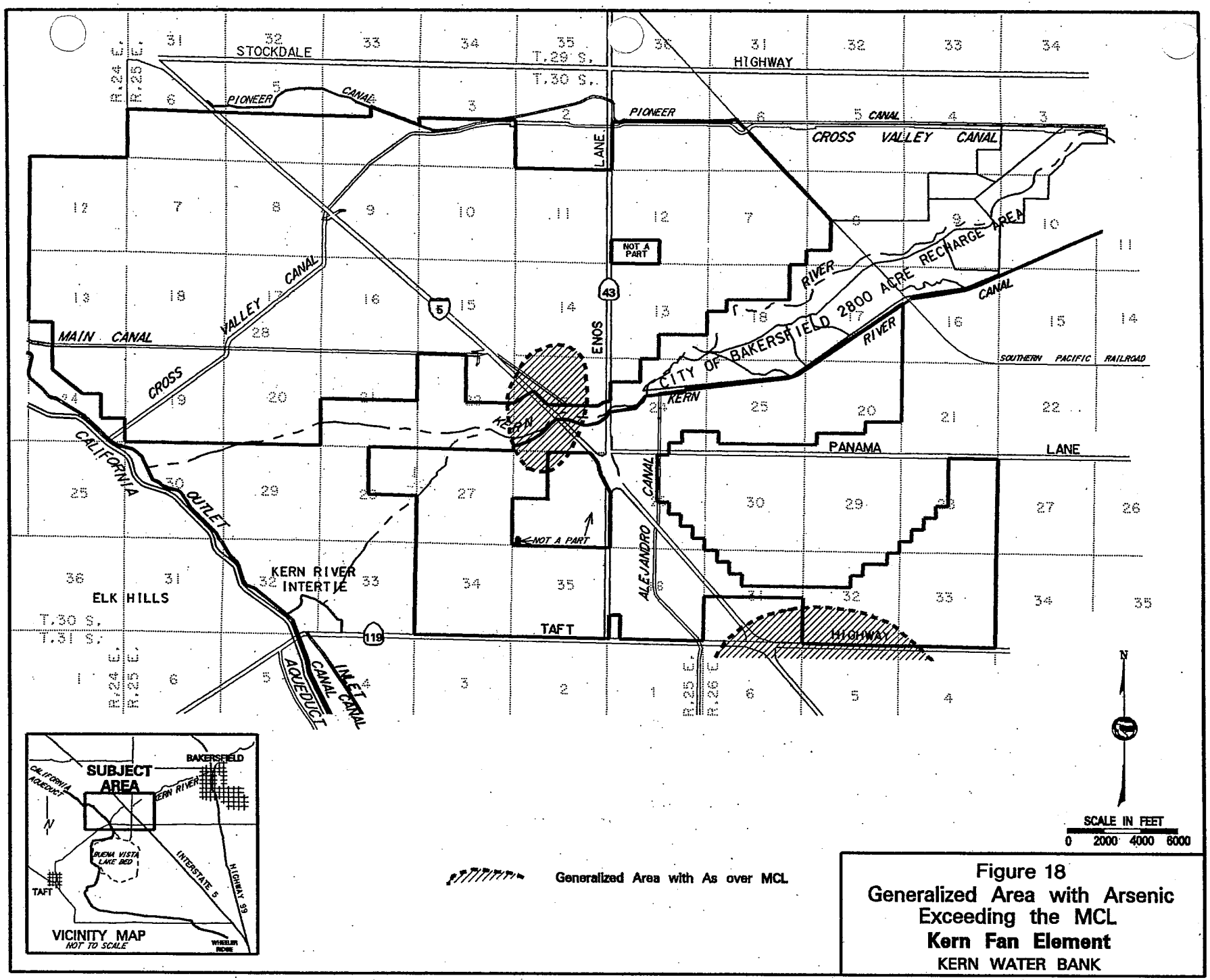



Figure 18
Generalized Area with Arsenic Exceeding the MCL
**Kern Fan Element**
KERN WATER BANK

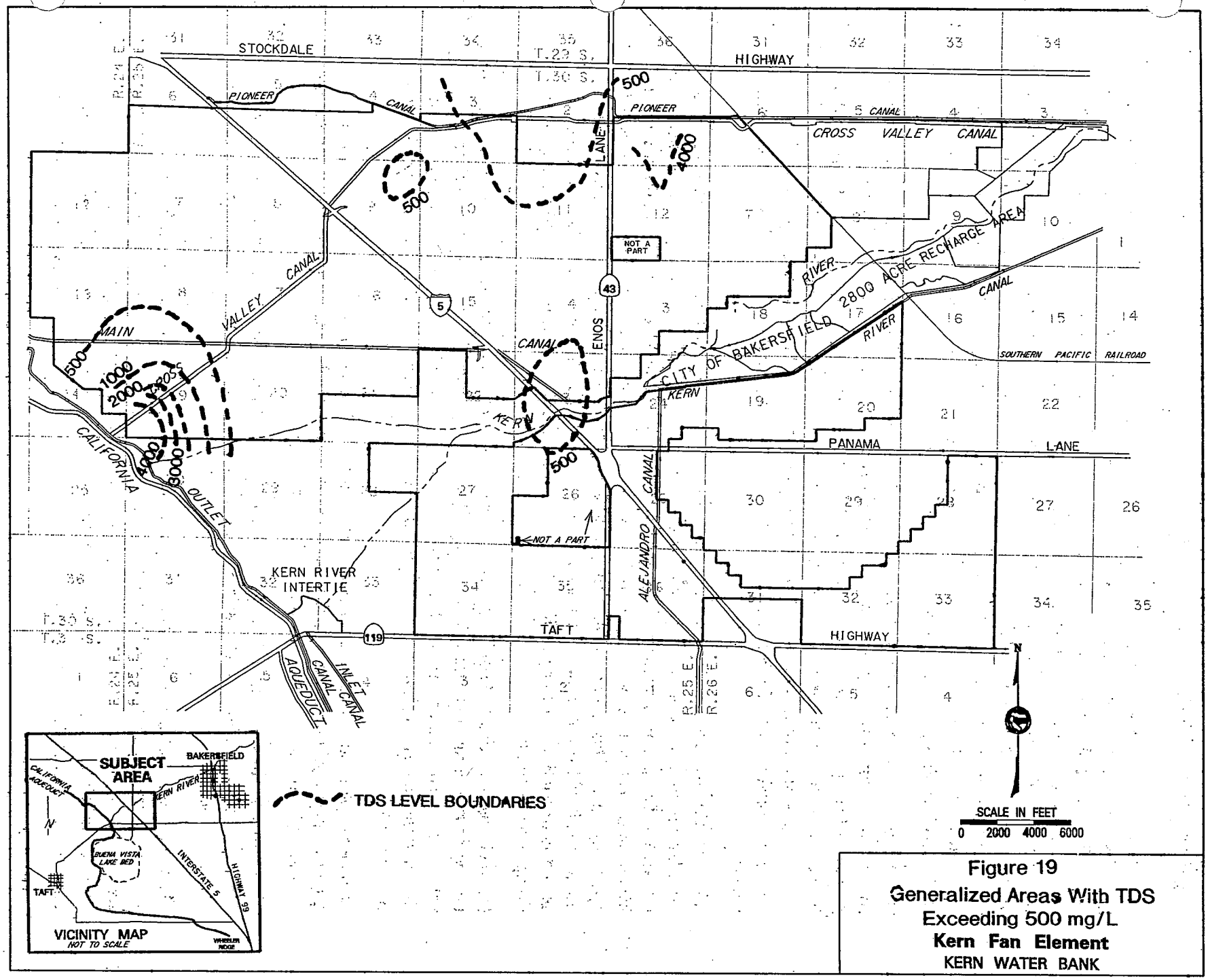



Figure 19
Generalized Areas With TDS Exceeding 500 mg/L
**Kern Fan Element**
KERN WATER BANK

## Implications of Water Quality Problems

The presence of areas with degraded water quality and the potential for identifying other degraded areas or future contamination will add a substantial element of operational complexity to the KFE. During planning, it was necessary to limit facility locations to avoid adversely influencing areas of poor ground water quality and incurring treatment or other costs that might be required to adhere to a policy of meeting all applicable drinking water MCLs and action levels for water delivered to a source of public water supply. These limitations have resulted in locating First Stage facilities away from the prime recharge areas, pending characterization of the extent of contamination in these areas. The following concerns have been, and will continue to be, considered in facility siting and operation:

(1) In areas with ground water contamination, recharge and extraction patterns must be carefully controlled to minimize the movement of contaminated water to extraction wells, through larger portions of the project area, and off the site where it may adversely affect neighboring properties. In the future, it may be necessary to develop a ground water transport model to optimize the location and operation of facilities. During the First Stage, this will be of particular concern in the area contaminated with EDB and the nearby areas with a significant likelihood of such contamination.

(2) Extraction wells will be located away from areas with known contamination, except where acceptable dilution rates or natural volatilization in open conveyance facilities will permit meeting of the MCLs. Extraction in areas with significant contamination may be necessary in the future, at which time treatment may be required. This will result in operational limitations and increased operating costs. This is not a significant problem for a carefully designed and operated First Stage, but it will become more significant as the project expands. One option that has been suggested is to continue farming on KFE lands in areas served by contaminated wells as a cleanup/dissipation method.

(3) Recharge facilities will not be located in areas with known soil contamination, and they should be operated in a manner that will not bring either recharge water or ground water into contact with areas of soil contamination. The First Stage facilities have been located in compliance with this criteria and will maintain a setback of 500 feet from petroleum pipelines (the major features of concern).

Detailed exploration at recharge sites will be required to demonstrate the absence of soil or ground water contamination. The results of this exploration will be used to confirm or modify the location of First Stage facilities, as indicated in this report.

Concerns about the potential for future water quality problems focus on the possibility of pesticide residue contamination (by leaching), and petroleum production facilities leakage. These are discussed below:

***Pesticides.*** Much of the project area has been under agricultural production for 20 to 40 years, and numerous pesticides have been applied (here used in a general sense to include fungicides, herbicides, nematicides, and other agricultural chemicals). However, long-term potential for contamination will decrease as farming is phased out. A number of pesticides (Table 3) that have a significant probability of reaching ground water have been identified for the ranking process de-

veloped for the AB 1803 program. While this list is not completely compatible with similar lists of contamination potential developed by others, it is considered to be reasonably representative. DWR will sample and monitor for those pesticides in Table 3 that have a history of use on KFE property.

Pesticide usage is a potential nonpoint contamination threat and, as such, is a threat throughout the portion of the project area that has been farmed. An exploration and sampling program is being conducted at each recharge site to identify the presence of potential contaminants. Four areas of potential point source contamination associated with pesticide storage and mixing are present on the property (Figure 20). The extent of soil and water contamination near these facilities is unknown and will require investigation prior to construction of any project facilities nearby.

**Table 3. Pesticides That Have a Significant Probability of Reaching Ground Water[1]**

| Rank One | Rank Two | |
|---|---|---|
| Alachlor | Benomyl | Diphenamid |
| Aldicarb[2] | BHC | Disulfoton |
| Atrazine | Bromacil | Endosulfoton |
| Carbofuran | Chlordane | Endothall |
| DBCP | Chloropicrin | Fenamiphos |
| 1,2-Dichloroproprane[3] | Cyanazine | Parathion |
| Dinoseb | Diazinon | Phorate |
| Diuron | Dimethoate | Prometryn |
| EDB (ethylene dibromide) | | |
| Oxamyl | | |
| Simazine | | |

1 Pesticides are potentially mobile and are applied directly onto or into the soil. Rank One pesticides have a very high probability of detection in ground water. Rank Two pesticides have some probability of detection in ground water.

2 Includes aldicarb sulfoxide and aldicarb sulfone.

3 Ingredient of concern in D-D mixture of a Rank Two pesticide.

***Petroleum Production.*** Two oil fields and parts of three others are present on the KFE, with production dating from the 1930s. Numerous pipelines used to transport petroleum products (Figure 21) cross the property, resulting in a significant potential for future soil and possibly ground water contamination with petroleum hydrocarbons. Problems with leakage have been detected along one pipeline alignment and future leaks can reasonably be expected along other pipeline alignments on the KFE property.

The operation of petroleum transportation pipelines is governed by the California Pipeline Safety Act of 1981 administered by the State Fire Marshall. Under this Act, jurisdictional pipelines must be periodically hydrotested (every three to five years) to ensure structural integrity. The hydrotesting procedure allows for a leakage rate that can be as large as ten gallons per hour (depending on the pipeline diameter and length of test section). If otherwise undetected, leakage at this rate could result in significant soil and ground water contamination.

Aerial inspection of the pipeline alignment also occurs frequently. However, aerial surveillance has limited utility in detecting leaks involving light crude that could move downward through the

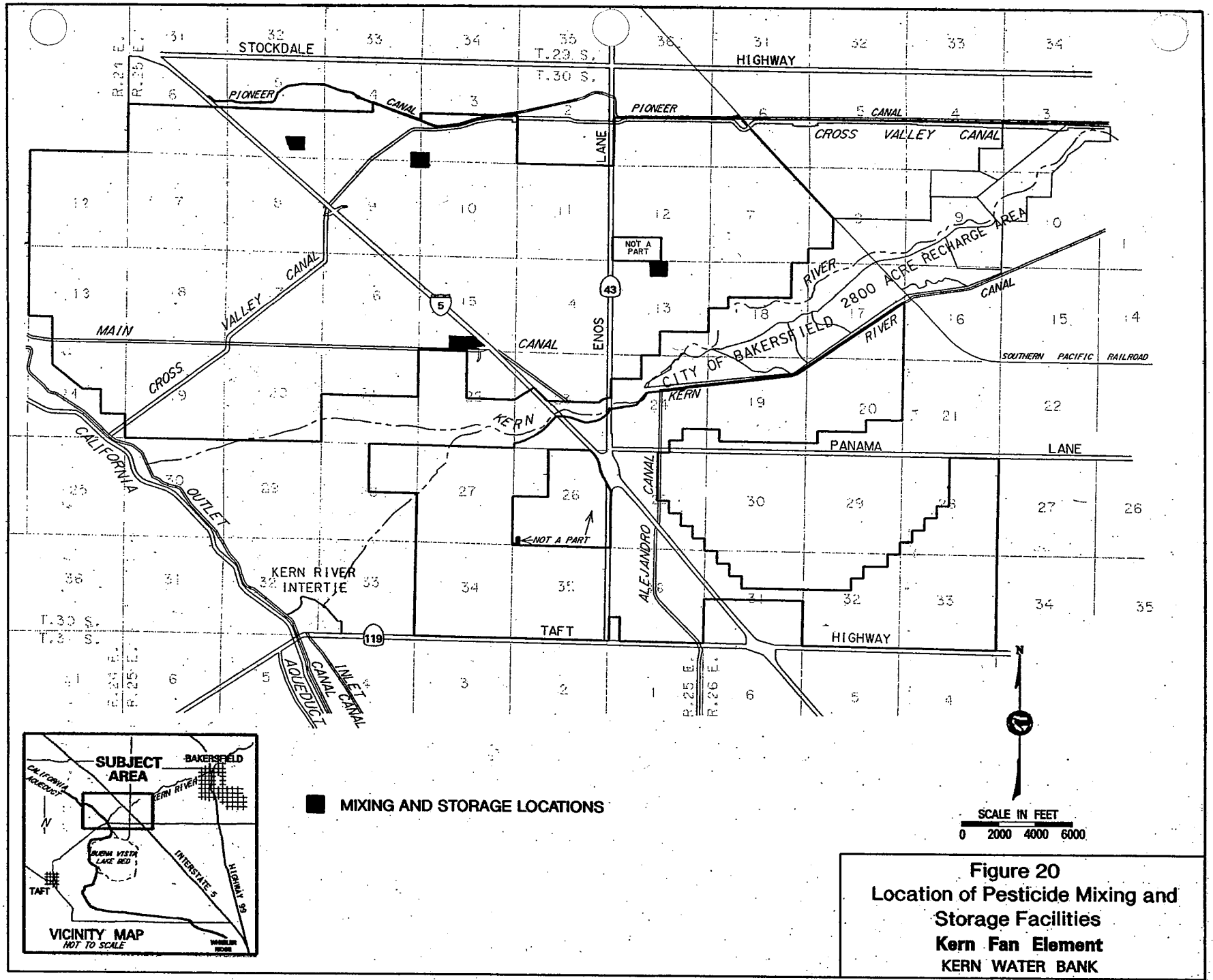



**Figure 20**
**Location of Pesticide Mixing and Storage Facilities**
**Kern Fan Element**
**KERN WATER BANK**

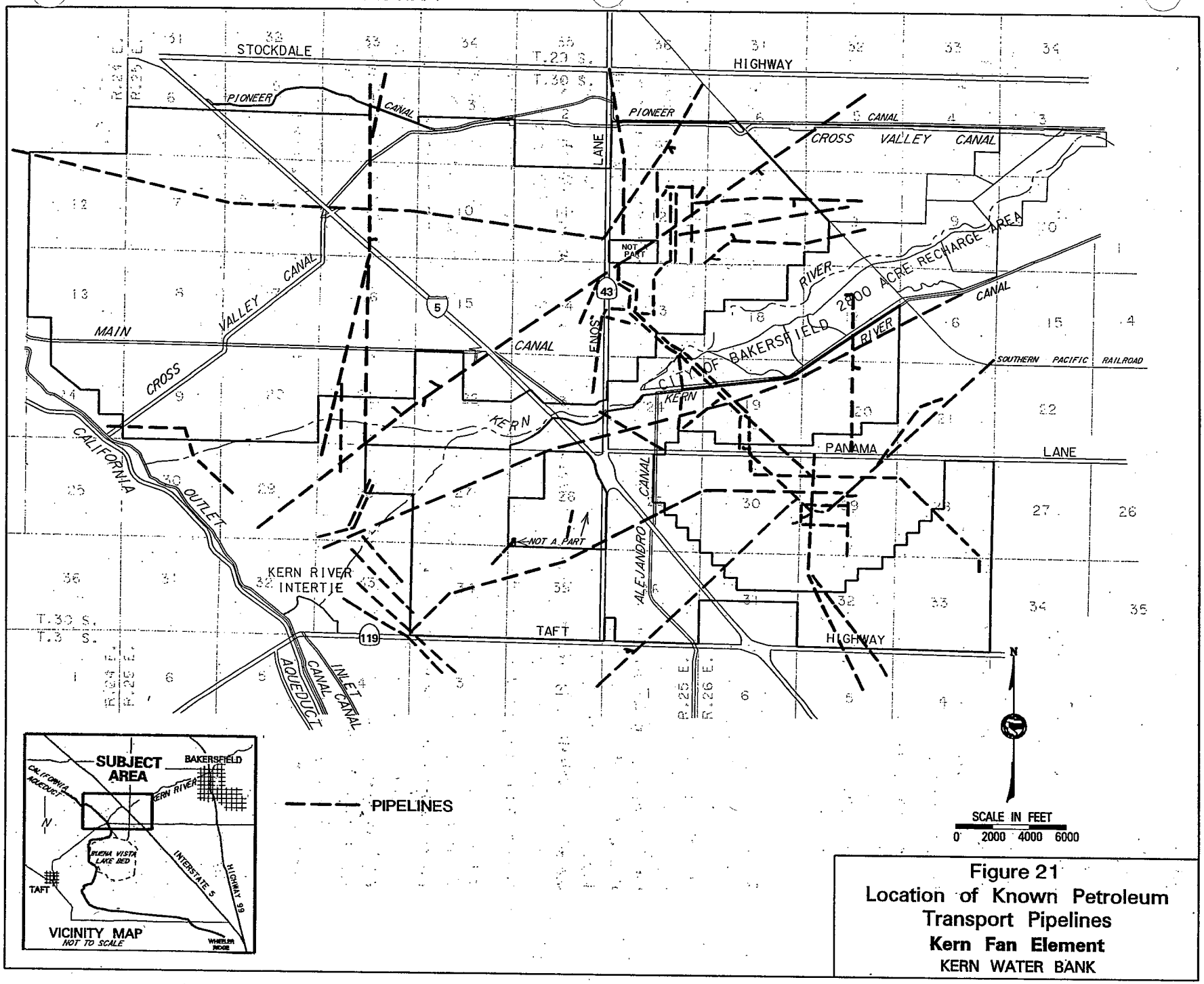



Figure 21
Location of Known Petroleum Transport Pipelines
**Kern Fan Element**
KERN WATER BANK

soil column. Such surveillance is more effective with heavy crude, which more readily reaches the surface. In addition, some pipelines may be nonjurisdictional and escape even minimal surveillance.

The strategy adopted for avoiding problems with possible pipeline contamination is one of maintaining setbacks of recharge facilities from known pipeline alignments. Recharge pond sites will be surveyed for unknown pipelines during the exploration phase before construction. Given the inadequacy of present pipeline surveillance requirements for detecting small leaks, DWR will evaluate the options that are available for monitoring pipelines with sufficient sensitivity to detect small leaks and will work toward implementation of a suitable methodology. The following options are being evaluated:

- Continuous monitoring of pipelines, using pressure point analysis
- Initial transfer gas survey
- Periodic surface air sampling for volatile components
- Periodic soil gas sampling for volatile components
- Other geophysical methods

Since detecting small leaks is difficult in areas where existing hydrocarbon contamination is widespread, some degree of risk of nondetection will be present and may be significant.

Oil fields in and around the KFE property have been used for petroleum production for many years. These production activities have a continuing potential to contaminate soil and ground water. Oil fields are generally regulated by the State Division of Oil and Gas, which performs inspection and surveillance. Other agencies, such as the Regional Water Quality Control Board and the Kern County Fire Department, regulate specific oil field activities. Soil samples have been collected at locations within the oil fields where repeated incidents of soil contamination have occurred (tank farms) and areas where spills have occurred. High levels of contamination are largely restricted to the upper 2 to 3 feet of soil, although volatile fractions may have penetrated deeper.

The continued use of sumps for disposal of brines and associated hydrocarbons presents the potential for contamination of ground water with both brine and soluble hydrocarbon fractions. The use of sumps should be phased out as soon as practicable. Most produced brine is presently disposed of by deep well injection and use of sumps is limited. Deep well injection is regulated under permits issued by the Division of Oil and Gas, which requires an annual mechanical integrity test (usually a radioactive tracer test) to be performed to ensure that brine does not contaminate fresh water. Properly constructed and maintained injection wells, as well as production wells, represent minimal water quality threats. Wells that are abandoned to present-day standards are of minimal concern. However, older wells not properly abandoned by today's standards may lack plugs at the base of fresh water or at the surface. Improperly abandoned wells could serve as conduits for the vertical movement of brines or hydrocarbons. Discussions with Division of Oil and Gas staff indicate that the producing zones have been depressurized and that contamination of fresh water is unlikely.

While the oil fields are aesthetically displeasing, they are not a significant impediment to project development, provided that recharge facilities are properly located and that water quality is adequately monitored. In general, since project recharge facilities will not be located in active oil fields, the soil contamination is not expected to be a significant threat to the project. However, a

monitoring well network will be installed to detect existing ground water contamination or any resulting from mobilization of hydrocarbons in the vadose zone by rising water levels.

The First Stage will be operated to avoid known adverse water quality impacts and periodic water quality measurements will be made. If problems arise, operations will be modified accordingly. The First Stage is not expected to involve or require any water treatment.

## Recharge and Extraction Concerns

It is impossible to plan for every concern that may arise from operation of the KFE. The following discussion describes general categories of potential problems and sets forth the kinds of solution that are possible. This discussion is organized into two topics: potential recharge water level and water quality concerns and potential extraction water level and water quality concerns.

***Recharge Water Level Concerns.*** Water levels are expected to rise on a regional basis during recharge operations. Local mounding is expected in the immediate area of the recharge basins. No off-site problems are anticipated. Each of the recharge basins will have a separate network of monitoring wells to gage the performance of recharge and the presence of mounding. Off-site mounding will be averted, to the extent practicable, by shifting recharge to other locations if problems occur.

The primary concerns with rising water levels are interference with long-term recharge performance and potential for liquefaction in response to earthquakes. These potential problems will be avoided by maintaining suitable water levels by modifying project operations, as necessary.

***Recharge Water Quality Concerns.*** The three primary recharge water quality concerns are: (1) percolation of water through contaminated soil; (2) elevation of regional ground water levels into contaminated soils within the current unsaturated zone (vadose zone); and (3) importation and recharge of water that has water quality problems (either higher salinity or potential pollutants).

A major concern to many of the SWP water contractors is the quality of the extracted water. Substantial field work and soil analyses in the areas of proposed SWP recharge basins indicates that the threat of percolating water through contaminated soil is minor. None of the soil sampled in the recharge basins to date has shown contamination. Shallow monitoring wells adjacent to each pond will be observed regularly, in addition to the deeper monitoring wells both on and off the property. Any areas that show potential contamination will be taken out of use until the problem is better defined and a solution is developed.

Recharge basins generally have been selected at locations that will limit water level increases in areas adjacent to pipelines and oil field operations. In the event of a problem (as evidenced by specific monitoring information), both recharge and extraction operations may need to be modified to provide some correction.

The potential for recharging water from the California Aqueduct having unacceptable levels of salt or other pollutants should not be significant since the First Stage recharge activities will occur primarily during the winter and spring months, when salinity in the Sacramento–San Joaquin Delta is relatively low. Delta salinity at the SWP export pumps is generally at or below the average salinity concentration of ground water on KFE property during the periods when recharge would occur. Salinity of both recharge and extraction water will be monitored to measure the net change

in salt load in the ground water basin. Potential pollutants will also be monitored. The First Stage is expected to improve salt balance conditions in the ground water basin.

***Extraction Water Level Concerns.*** Ground water levels will be monitored to prevent unacceptable water level impacts to surrounding users. Two operational modes will be used to respond to potential adverse impacts. First, pumping will be shifted away from potential problem areas. Second, water users directly impacted by KFE operations will be compensated. Sufficient flexibility is expected to be provided in extraction facilities to avoid operational problems. First Stage extraction sites have been distributed over much of the property to avoid interference impacts. Most wells are considerably inside the property boundary. DWR has developed both on-site (described in the Mitigation Chapter) and off-site ground water monitoring networks that are acceptable to surrounding water districts. The off-site network will involve construction of a substantial number of monitoring wells within two miles of the KFE property boundary, as well as use of supplemental information from existing monitoring wells in surrounding areas. The off-site network will be constructed and placed in operation before First Stage extraction begins.

The project will be designed and operated to avoid adverse impacts. Therefore, compensation for adverse impacts should not be required. However, DWR will develop specific procedures as part of the operating agreement with KCWA for determining when adverse impacts have occurred or may occur, and provide a means to resolve the problem. Consideration will be given to the positive benefits to ground water levels projected to result from operation of the KFE, including the offsetting benefits of phasing out the 26,000 AF per year of net ground water use on the property. Such net annual use in the long term is assumed to have been met by continued overdraft of the ground water basin, leading to the conclusion that the phase-out of farming directly reduces overdraft.

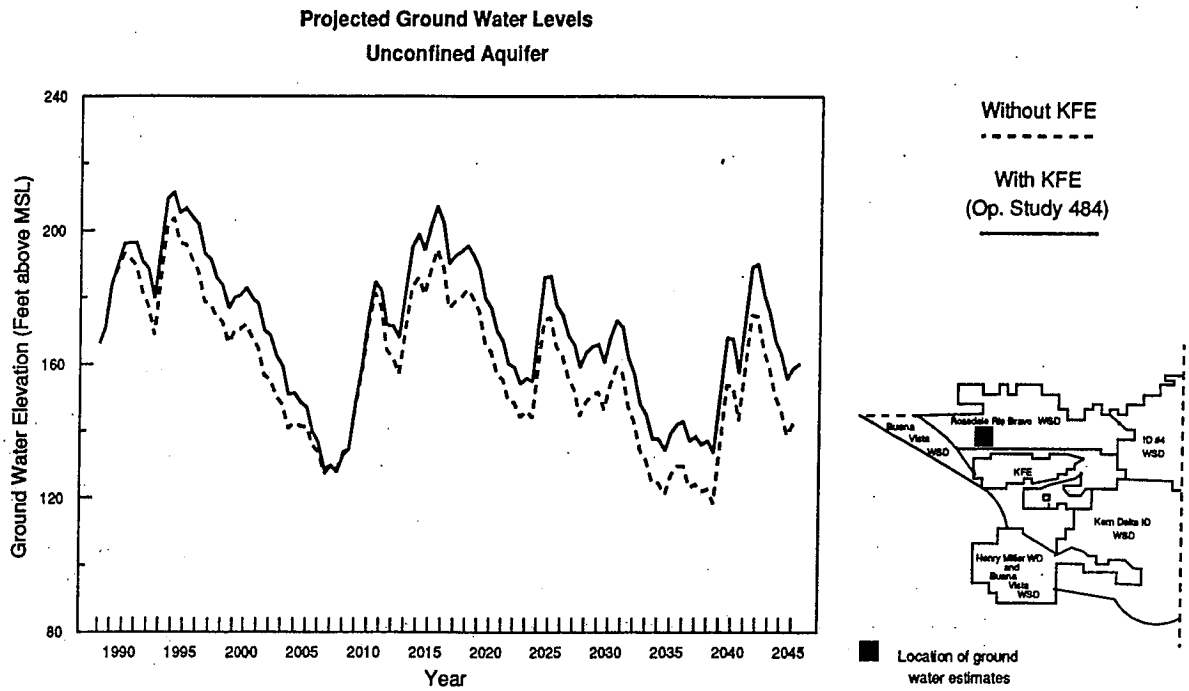
A basinwide ground water model (GWM) was used to project KFE impacts. The water model is an adaptation of the San Joaquin Valley Ground Water Model originally developed for DWR by Resource Management Associates and documented by RMA in 1982 (RMA, 1982). After its initial development, the Valley-wide ground water model was modified in DWR studies described in DWR reports in 1985 and 1989. The basinwide GWM used in KFE studies was adapted by truncation to exclude most of the Valley outside of Kern County and by addition of detail in the vicinity of the KFE.

The results of the basinwide GWM projections are summarized in two sets of figures: (1) hydrographs that show water levels at specific elements for each projection year and (2) contour maps that show ground water impacts adjacent to the KFE for specific projection years. Figure 22 shows hydrographs of projected GWM unconfined water levels for four elements. In reviewing these hydrographs, the reader should consider that any projected ground water level rises or declines reflect not only the projected KFE recharge and extraction activities but also the impacts of alternating wet and dry hydrologic cycles for Kern County as a whole.

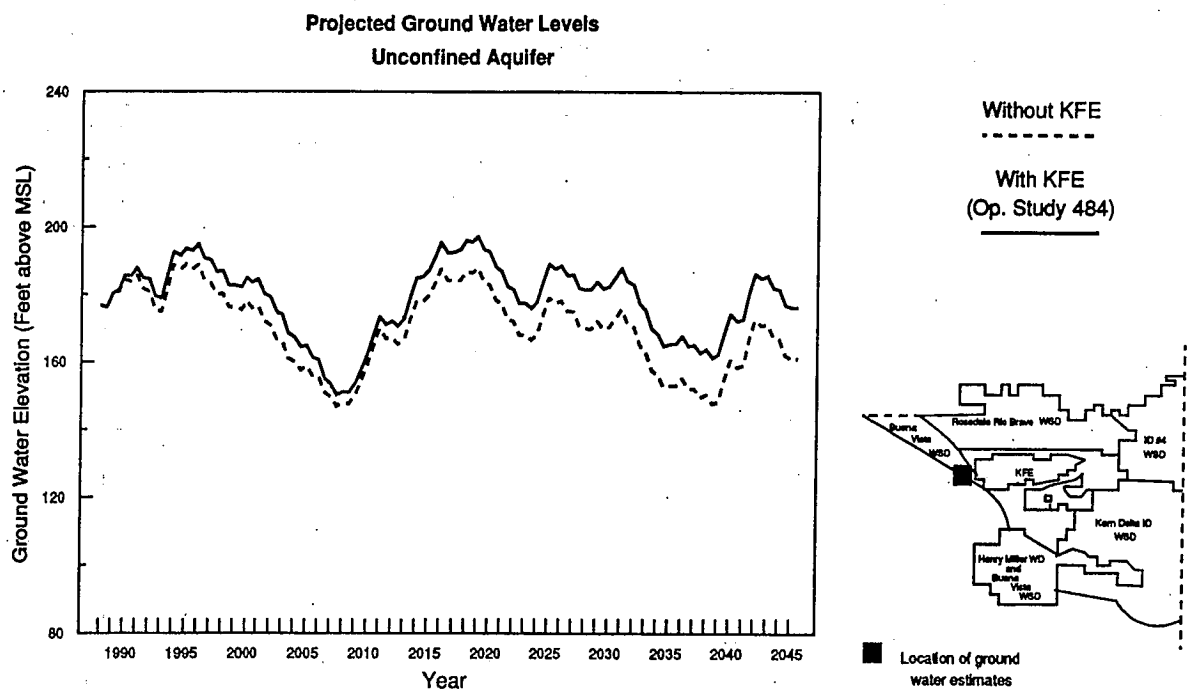
Two periods of years in these hydrographs are especially important for project operations — the initial fill period and the critical period for extractions. The initial fill period starts in the second year of the projections, 1989, which is assumed to be a relatively wet year corresponding to hydrologic year 1974. As shown in Table 4, KFE recharge continues at large rates through projected year 1995, when the KFE reaches maximum project storage. This initial fill period includes the hydrologic sequence of 1974 through 1978, followed by 1922 and 1923. The critical extraction

## Figure 22

# Element 221 (Rosedale-Rio Bravo WSD)

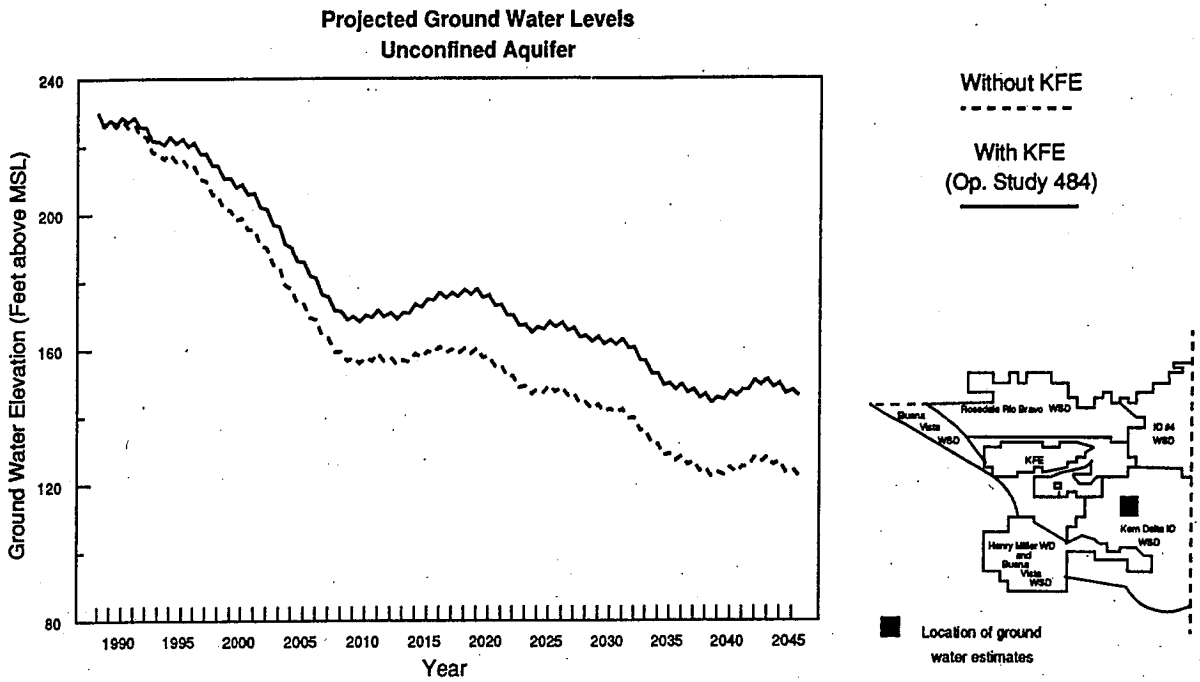



# Element 219 (Buena Vista WSD)

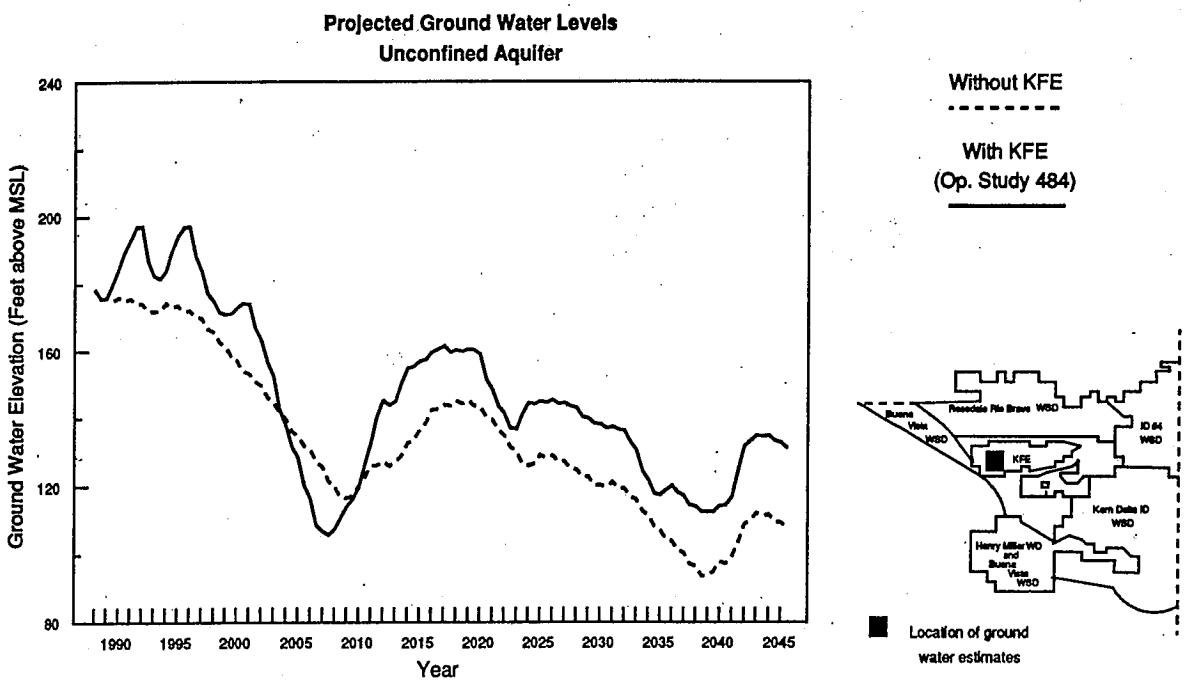


## Figure 22 cont.

# Element 250 (Kern Delta WD)




# Element 224 (Kern Fan Element)



period corresponds hydrologically to the SWP's 1929-1935 seven-year critically dry period. The projection years equivalent to this critical period are 2001 through 2007.

The first of the hydrographs in Figure 22 is for Element 221, located in Rosedale–Rio Bravo WSD less than one mile from the northern boundary of the KFE. The hydrograph for this element shows higher water levels with KFE operations than without for all but one year near the end of the 1929–1935 dry period. Projected with–KFE water levels during 2007, which corresponds with hydrologic year 1935, are a maximum of 0.3 feet lower than projected without–KFE water levels. Over the entire 57–year simulation period, projected GWM unconfined water levels with KFE operations in Element 221 average 12.4 feet higher than without–project conditions. Because Element 221 is closer to the KFE than is most of Rosedale–Rio Bravo WSD, it somewhat exaggerates the impacts, both positive and negative, of KFE operations on ground water levels. The average water level increase throughout Rosedale–Rio Bravo WSD due to KFE operations is less than the 12.4 feet in Element 221, but most other elements also do not have any periods of time in which unconfined water levels are lower with the KFE than without it. Hydrographs for Elements 219 and 250, which are located in Buena Vista WSD and Kern Delta WD, respectively, both show projected unconfined water levels that are always higher with than without KFE operations. On the average, projected unconfined water levels are 8.5 and 11.4 feet higher for Elements 219 and 250 with the KFE.

The final hydrograph shown is for Element 224, which is located within the KFE. The benefits of higher water levels in recharge years are pronounced in this element, as are the impacts of dry year extraction. Water levels in Element 224 with the KFE are projected to rise about 33 feet higher than they would have without the project during intensive recharge during the initial fill period. Later, during peak extraction in the projected 2001-through-2007 period (which corresponds hydrologically with the 1929–1935 dry period), projected with–KFE water levels fall as much as 11.4 feet below without–project levels. These project impacts occur within the KFE itself and are not indicative of impacts to other basin water users.

A second summary of the GWM projections shows the impacts of project operations for two different periods. First, Figure 23 is a contour map that shows the difference between with–project and without–project water levels for projection year 1991, which corresponds hydrologically to spring 1976 conditions. These conditions represent the effects of three years of full recharge operations with KFE storage about 75 percent full. Figure 24 is another contour map that shows the difference between with-project and without–project water levels in the KFE for projection year 2007. This contour map shows the effects of complete withdrawal of SWP storage near the end of the 1929–1935 dry period.

Finally, a complete measure of KFE impacts is provided in Table 4. This table presents the difference between total pumping costs with and without the KFE for nearby Kern County DAUs. Using an interest factor of 6 percent, a real increase in energy costs of 1.7 percent, and a 50-year analysis period, the KFE results in present worth of reduced pumping costs of $2,500,000 for DAU 454 (Rosedale–Rio Bravo WSD and an adjacent unorganized area to the north), $500,000 for DAU 355 (Buena Vista WSD), and $9,500,000 for DAU 354 (KCWA Improvement District No. 4, Kern Delta WD and the non–SWP portions of the former James–Pioneer Improvement District).

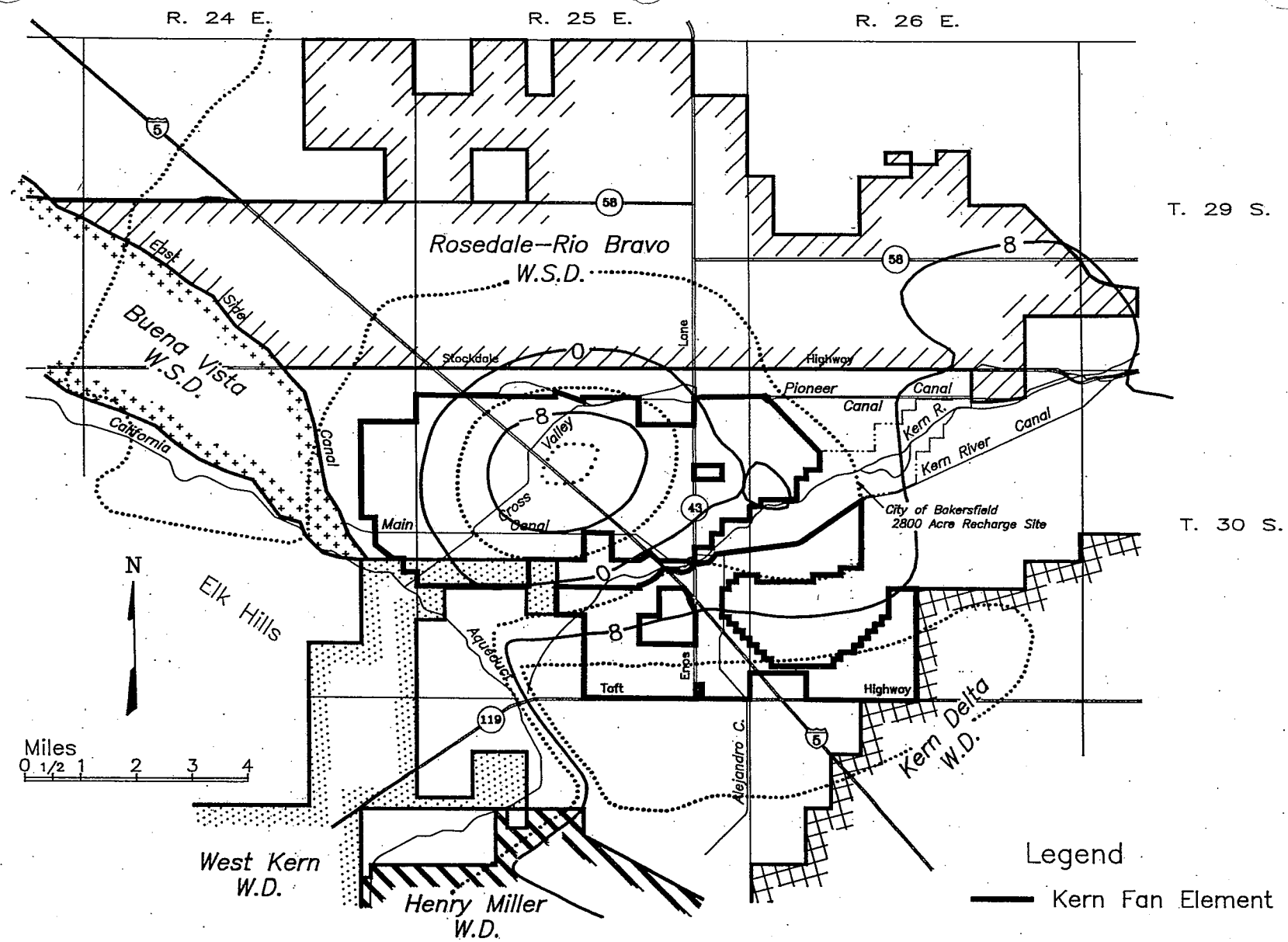



**Figure 23 UNCONFINED WATER LEVEL IMPACTS (1975)**

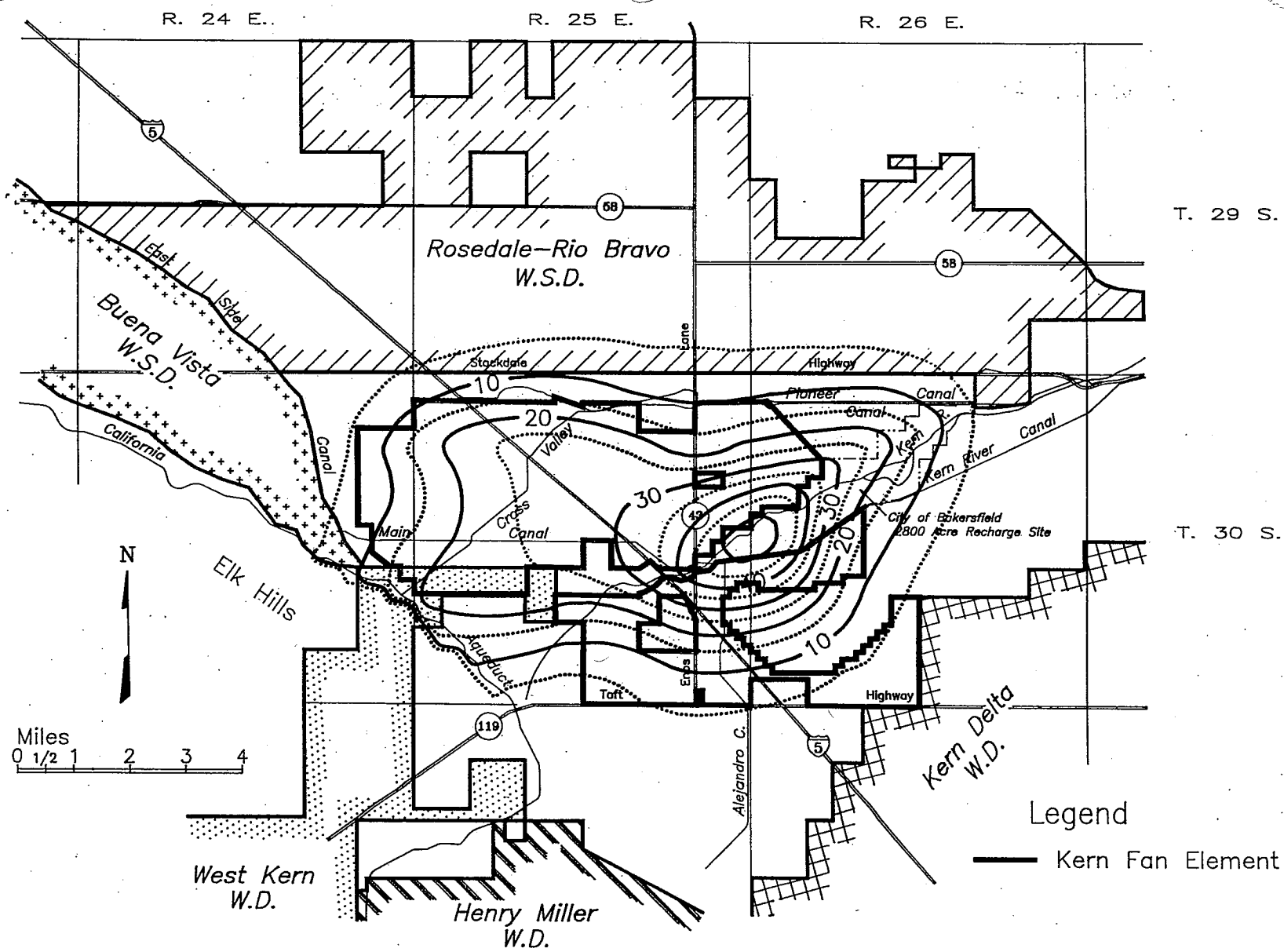



**Figure 24 UNCONFINED WATER LEVEL IMPACTS (1935)**

## Table 4
### PROJECTED TOTAL KERN FAN ELEMENT PUMPING COSTS SAVINGS
(Difference between total pumping costs with and without KFE)
($MILLIONS)

| DAU | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 354 | 0.13 | 0.20 | 0.13 | 0.20 | 0.21 | 0.64 | 0.25 | 0.30 | 0.56 | 0.42 | 0.48 | 0.50 |
| 454 | -0.01 | 0.01 | 0.05 | 0.10 | 0.08 | 0.10 | 0.14 | 0.19 | 0.17 | 0.17 | 0.18 | 0.20 |
| 554 | -0.22 | 0.45 | 0.70 | 0.85 | -0.95 | -0.04 | 0.89 | 0.92 | -0.49 | -0.23 | 0.14 | 0.98 |
| 654 | 0.00 | 0.00 | 0.01 | 0.03 | 0.03 | 0.00 | 0.01 | 0.00 | 0.17 | 0.01 | 0.02 | 0.00 |
| 754 | 0.00 | 0.00 | 0.00 | 0.41 | 0.11 | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.47 | 0.00 |
| 854 | -0.01 | 0.01 | 0.04 | 0.06 | 0.03 | 0.03 | 0.06 | 0.07 | 0.05 | 0.06 | 0.06 | 0.07 |
| 355 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.00 | 0.01 | 0.14 | 0.02 | 0.03 | 0.00 |
| 455 | 0.00 | 0.00 | 0.02 | 0.07 | 0.01 | 0.02 | 0.04 | 0.06 | 0.44 | 0.04 | 0.05 | 0.08 |
| 555 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.02 | 0.01 | 0.00 | 0.01 |
| 256 | 0.00 | 0.00 | 0.00 | 0.02 | 0.04 | 0.01 | 0.03 | 0.04 | 0.19 | 0.08 | 0.10 | 0.08 |

| DAU | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 354 | 0.56 | 0.85 | 0.72 | 0.79 | 0.61 | 0.62 | 0.65 | 0.49 | 0.68 | 1.34 | 1.40 | 0.68 |
| 454 | 0.22 | 0.21 | 0.22 | 0.18 | 0.18 | 0.13 | 0.11 | 0.12 | 0.15 | 0.12 | 0.14 | 0.19 |
| 554 | 1.13 | -0.53 | 0.15 | -1.70 | -0.73 | -1.95 | -1.82 | 0.20 | 1.38 | -1.05 | 0.00 | 1.53 |
| 654 | 0.00 | 0.19 | 0.05 | 0.11 | 0.02 | 0.06 | 0.03 | -0.05 | 0.04 | -0.01 | -0.01 | 0.01 |
| 754 | 0.70 | 0.15 | 0.62 | 0.10 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 854 | 0.08 | 0.07 | 0.07 | 0.04 | 0.05 | 0.03 | 0.02 | 0.03 | 0.05 | 0.02 | 0.03 | 0.06 |
| 355 | 0.03 | 0.18 | 0.08 | 0.10 | 0.02 | 0.03 | 0.04 | -0.03 | 0.00 | 0.00 | 0.00 | 0.01 |
| 455 | 0.10 | 0.56 | 0.19 | 0.32 | 0.11 | 0.19 | 0.14 | -0.11 | 0.24 | 0.01 | 0.10 | 0.14 |
| 555 | 0.01 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.00 | 0.01 | 0.01 | 0.01 | 0.01 |
| 256 | 0.11 | 0.30 | 0.21 | 0.28 | 0.16 | 0.20 | 0.24 | 0.12 | 0.17 | 0.05 | 0.05 | 0.18 |

| DAU | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 354 | 0.85 | 1.60 | 1.21 | 1.72 | 1.30 | 1.57 | 1.39 | 1.41 | 1.36 | 1.53 | 1.45 | 1.32 |
| 454 | 0.23 | 0.25 | 0.30 | 0.33 | 0.35 | 0.34 | 0.38 | 0.40 | 0.37 | 0.35 | 0.34 | 0.40 |
| 554 | 0.93 | 0.00 | 0.89 | 0.00 | 0.43 | -0.15 | 1.09 | 1.08 | -0.49 | -0.61 | 0.12 | 2.02 |
| 654 | 0.07 | 0.00 | 0.00 | 0.00 | 0.20 | 0.04 | 0.00 | 0.08 | -0.01 | 0.10 | 0.00 | 0.00 |
| 754 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.53 | 0.00 | 0.00 |
| 854 | 0.07 | 0.06 | 0.10 | 0.10 | 0.11 | 0.10 | 0.11 | 0.11 | 0.09 | 0.09 | 0.09 | 0.12 |
| 355 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.09 | 0.05 | 0.13 | 0.05 | 0.00 |
| 455 | 0.40 | 0.18 | 0.17 | 0.18 | 0.72 | 0.28 | 0.22 | 0.39 | 0.12 | 0.46 | 0.17 | 0.27 |
| 555 | 0.02 | 0.02 | 0.02 | 0.02 | 0.04 | 0.03 | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| 256 | 0.27 | 0.09 | 0.16 | 0.11 | 0.42 | 0.23 | 0.24 | 0.41 | 0.39 | 0.51 | 0.42 | 0.37 |

| DAU | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 354 | 2.33 | 1.66 | 1.66 | 2.22 | 2.05 | 1.80 | 2.62 | 2.48 | 2.80 | 2.81 | 2.54 | 2.53 |
| 454 | 0.41 | 0.46 | 0.49 | 0.53 | 0.53 | 0.56 | 0.55 | 0.60 | 0.59 | 0.58 | 0.58 | 0.63 |
| 554 | 0.00 | 1.58 | 1.98 | 1.74 | 1.07 | 2.18 | 0.47 | 2.29 | 0.66 | -0.25 | 0.20 | 1.97 |
| 654 | 0.00 | 0.00 | 0.01 | 0.30 | 0.03 | 0.01 | 0.00 | 0.23 | 0.36 | 0.26 | 0.19 | 0.01 |
| 754 | 0.00 | 0.00 | 0.00 | 0.18 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 0.76 | 0.00 | 0.00 |
| 854 | 0.11 | 0.14 | 0.15 | 0.15 | 0.14 | 0.16 | 0.14 | 0.17 | 0.14 | 0.13 | 0.14 | 0.16 |
| 355 | 0.00 | 0.00 | 0.05 | 0.33 | 0.00 | 0.03 | 0.00 | 0.28 | 0.46 | 0.41 | 0.22 | 0.00 |
| 455 | 0.28 | 0.30 | 0.32 | 1.20 | 0.47 | 0.40 | 0.40 | 1.18 | 1.39 | 1.15 | 0.96 | 0.56 |
| 555 | 0.03 | 0.03 | 0.03 | 0.06 | 0.05 | 0.05 | 0.05 | 0.07 | 0.08 | 0.08 | 0.07 | 0.07 |
| 256 | 0.15 | 0.40 | 0.48 | 0.82 | 0.41 | 0.54 | 0.36 | 0.89 | 1.16 | 1.20 | 0.90 | 0.58 |

| DAU | 2036 | 2037 | 2038 | 2039 | 2040 | 2041 | 2042 | 2043 | 2044 | 2045 |
|---|---|---|---|---|---|---|---|---|---|---|
| 354 | 2.65 | 2.53 | 2.88 | 3.87 | 3.09 | 2.69 | 3.72 | 3.30 | 3.58 | 3.65 |
| 454 | 0.67 | 0.70 | 0.76 | 0.74 | 0.79 | 0.78 | 0.83 | 0.88 | 0.90 | 0.91 |
| 554 | 2.28 | 2.36 | 2.91 | 0.00 | 2.47 | 0.00 | 1.84 | 2.82 | 2.96 | 1.92 |
| 654 | 0.19 | 0.03 | 0.18 | 0.00 | 0.14 | 0.00 | 0.25 | 0.05 | 0.04 | 0.00 |
| 754 | 0.33 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 | 0.00 |
| 854 | 0.18 | 0.19 | 0.21 | 0.18 | 0.20 | 0.18 | 0.21 | 0.23 | 0.24 | 0.24 |
| 355 | 0.22 | 0.06 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.14 | 0.27 | 0.00 |
| 455 | 1.16 | 0.69 | 1.31 | 0.72 | 1.22 | 0.78 | 1.72 | 0.95 | 0.84 | 0.85 |
| 555 | 0.08 | 0.08 | 0.10 | 0.08 | 0.11 | 0.09 | 0.12 | 0.11 | 0.11 | 0.11 |
| 256 | 1.00 | 0.81 | 1.07 | 0.26 | 1.02 | 0.26 | 1.08 | 1.18 | 1.34 | 0.89 |

***Extraction Water Quality Concerns.*** This category deals with potential problems with quality of water extracted from any of the wells on the property. Potential problems include pesticide residues left over from historical farming operations, hydrocarbon contamination from oil and gas operations, and high salt concentrations resulting from plumes of historically percolated oil field brine and/or intrusion of high–salinity water from the west side of the valley. The general solution to this category of problems is to identify the cause of the problem, shift production away from the problem well(s), and modify project operation. To effectively evaluate the impact of modified project operations and to define facility location and operational characteristics needed to control movement of contaminants may require development of a ground water transport model. The ultimate solution in the case of contamination includes control of the source (including clean–up as needed). In addition, it may require development of treatment options for extracted water if MCLs cannot otherwise be met before delivery into a source of public water supply. Treatment options will be very costly and should be resorted to only if operational modification is insufficient to control a water quality problem.

A low level of pesticide contamination is present in some areas, but the water quality is acceptable for irrigation. A potential clean-up option would involve continued use of the contaminated wells for irrigation on KFE lands, if such activity improves the quality of ground water. This solution would require amending the 1987 MOU and postponing a portion of the agricultural phase–out beyond the five–year requirement. Another potential solution is to allow the discharge of such contaminated water into the CVC when it is being used only for irrigation for a substantial period of time. This potential solution would have to be worked out with the CVC Participants and closely coordinated with the agricultural users and Improvement District No. 4.

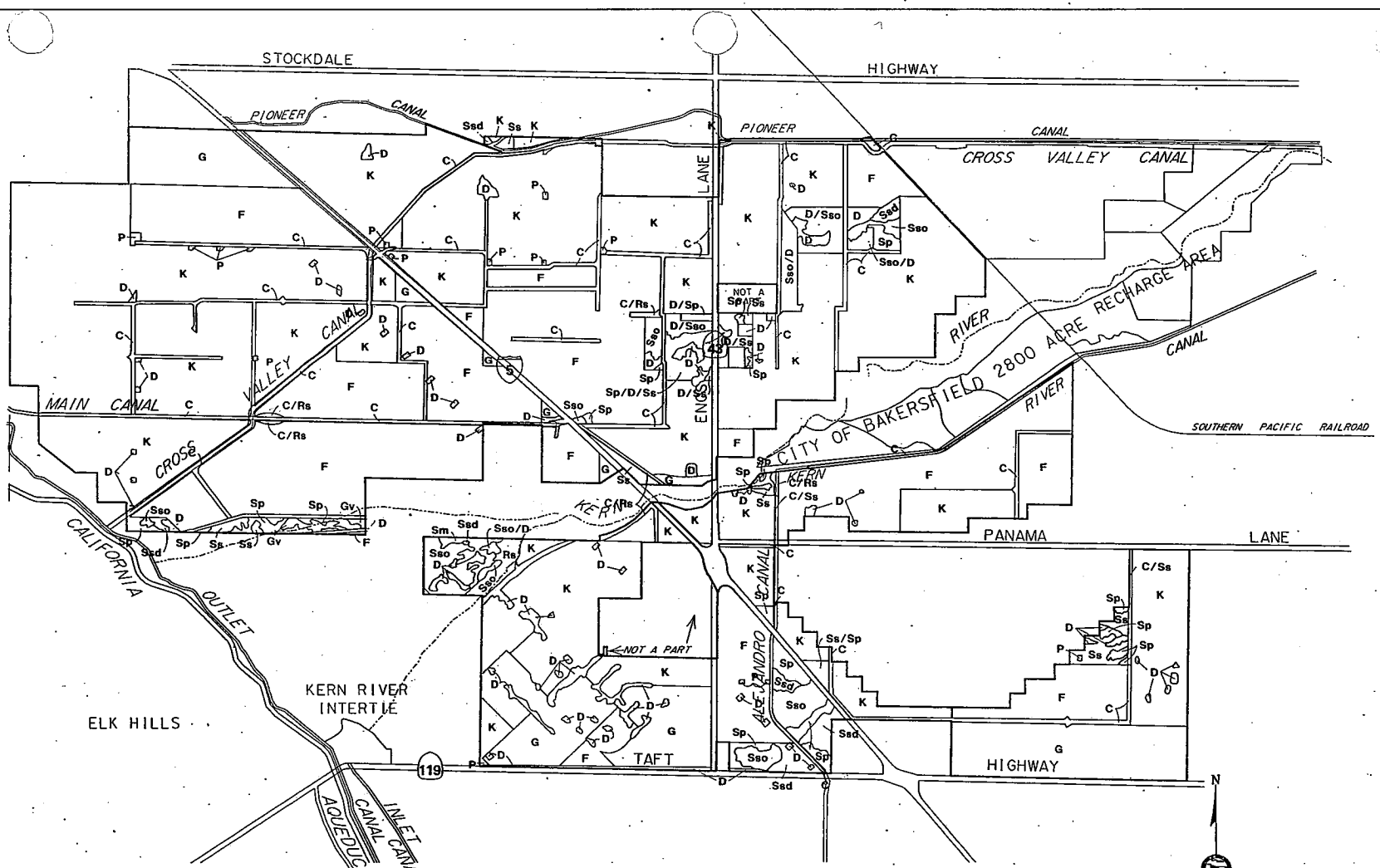
## VEGETATION

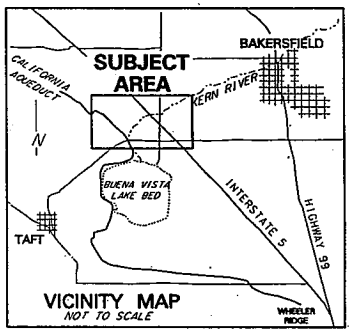
Six natural vegetation communities and five agricultural and/or disturbed areas are represented within the KFE project boundary. The acreage of the project is about 20,000 acres with native vegetation present on 1,510 acres. A more detailed description of vegetation communities is contained in the 1986 Program EIR. Vegetation types were delineated on 7.5 minute (1:24,000 scale) U.S. Geological Survey quadrangle maps. Vegetation maps were generated from these maps (see Figure 25). A list of "sensitive plants" (Appendix A) was compiled, using the rare plant inventory of the California Native Plant Society (CNPS, 1989), and the California Department of Fish and Game (DFG) and U.S. Fish and Wildlife Service (FWS, February 1990) lists of threatened, endangered, and/or candidate species. The following section describes vegetation types mapped and the dominant species found during the spring and summer of 1990. The vegetation types follow the designations defined by Holland (1985).

No significant impacts to native vegetation are expected since no construction or operation activities are contemplated in areas of native vegetation.

### Valley Saltbush Scrub – Open/Dense (So/Sd)

This scrub community is found on sandy–loamy soils without surface alkalinity. The dominant species are *Atriplex polycarpa* with association of other *Atriplex* species. Open stands of valley saltbush scrub contain less than 35 percent cover of saltbush. Dense stands of valley saltbush contain greater than 35 percent cover. Saltbush communities may occur in association with other natural vegetation on the project areas, particularly as an understory of the mesquite savanna.




**VEGETATION AND OTHER**

G–Non-Native Grassland
K–Agriculture
F–Fallow Field
D–Disturbance
C–Canal
P–Pond
Gv–Valley Sacaton Grassland
Rs–Southern Cottonwood Willow Riparian Forest
Sf–Cottonwood Savanna
Sm–Mulefat Scrub
Sp–Valley Mesquite Savanna
Sso/Ssd–Valley Saltbush Scrub (Open/Dense)

**Figure 25**

**Vegetation Communities**

**Kern Fan Element**

**KERN WATER BANK**

## Non-Native Grassland (G)

This community is found on fine-textured, usually clay soils. A sparse to dense cover of annual grasses including *Avena* spp., *Bromus* spp., and *Erodium* spp. is generally found in this area. Non-native grass communities may occur in association with native annual forbs, especially in years of favorable rainfall. Typical species include *Avena barbata, A. fatua, Bromus mollis, B. rubens, Erodium botrys, E. cicutarium, Eschscholzia californica, Gilia* spp., *Hemizonia* spp., *Lasthenia* spp., *Layia* spp., *Lupinus* spp., and *Lepidium dictyotum.*

## Valley Sacaton Grassland (Gv)

This community contains a mid-height (to 3 feet) tussock forming grassland dominated by *Sporobolus airoides.* The community occurs on fine-textured, poorly drained, usually alkaline soils. Most sites have seasonally high water tables or are overflowed during winter flooding. Typical species include *Distichis spicata, Hordeum depressum,* and *Sporobulus airoides.*

## Mulefat Scrub (Sm)

This community is found along intermittent stream channels with fairly course substrate and moderate depth to the water table. The dominant species is Baccharis viminea which is maintained by frequent flooding. Typical species include *Baccharis viminea, Salix* spp., and species from the Family Cyperaceae.

## Great Valley Mesquite Savanna (Sp)

This community is found on sandy loams of alluvial origins. The dominant species are *Prosopis juliflora* var. *torreyana* and *Atriplex* spp. Cover density ranges from open woodland to savanna. Understories are grassy in years of good rainfall, though usually dominated by introduced annuals. Mesquite is adapted to hot, dry summers and moist, foggy winters. Typical species include *Atriplex* spp., *Bromus rubens, Haplopappus acradenius,* var. *bracteosus, Prosopis juliflora* var. *torreyana.*

## Southern Cottonwood Willow Riparian Forest (Rs)

This tall, open broadleafed winter-deciduous riparian community is dominated by *Populus fremontii* and several tree willows. The dominant species require moist, bare mineral soil for germination and establishment. Typical species include *Baccharis viminea, Populus fremontii,* and *Salix* spp.

## Canal (C)

Canals have been constructed throughout the project area to transport water for irrigation. Where maintenance takes place, canal areas are devoid of vegetation. Other canals may include any of the above communities, particularly those with species including *Baccharis, Salix,* and *Populus.*

## Pond (P)

Impoundment areas storing water for irrigation or livestock.

## Disturbed (D)

This includes areas which have been impacted by heavy equipment and/or current or past construction leaving the ground devoid of vegetation.

## Agriculture (K)

Areas currently used for agricultural production. Major crops include cotton, alfalfa, and grain.

## Fallow Field (F)

Areas previously under agricultural use but which are currently fallow. Fallow fields may grade with or revert to non-native grassland.

# WILDLIFE

DFG, under contract to DWR, conducted an inventory of the reptiles and amphibians, birds, and mammals inhabiting and/or foraging on the KFE property. The inventory began in June 20, 1990, and concluded at the end of November 1990. Special emphasis was given to listed species that potentially could be impacted by pond construction on the property. The primary species of concern are the federal and State endangered blunt-nosed leopard lizard (*Gambelia silus)* and Tipton's kangaroo rat (*Dipodmys nitratoides nitratoides)*, and the federally listed endangered, State listed threatened San Joaquin kit fox *(Vulpes macrotis mutica).*

Several field techniques were used to evaluate the potential use of the property by wildlife. The methodologies included: walking transects, riparian transects, raptors routes, spotlight surveys, track pads, variable circular plots, and small mammal trapping. Trapping efforts were random, with most of the effort concentrated in the proposed pond areas. The following sections identify species inventoried on the KFE property. Appendix B contains a list of the species found on the KFE property. Figure 26 shows the general locations of the threatened and endangered species on the KFE property.

A phased study approach was used by DFG to coincide with the First Stage program. The information that results from the DFG studies will be used, along with the operation and extraction results of the First Stage, to refine the ultimate layout of facilities for the KFE.

## Reptiles and Amphibians

Intensive ground surveys for reptiles and amphibians were conducted from June through October 1990. The areas surveyed were the proposed First Stage recharge pond sites, fallow fields, and native habitat. Seven common reptile species and the State and federally listed endangered blunt-nosed leopard lizard were sighted on the KFE property. No amphibians were observed on the KFE property.

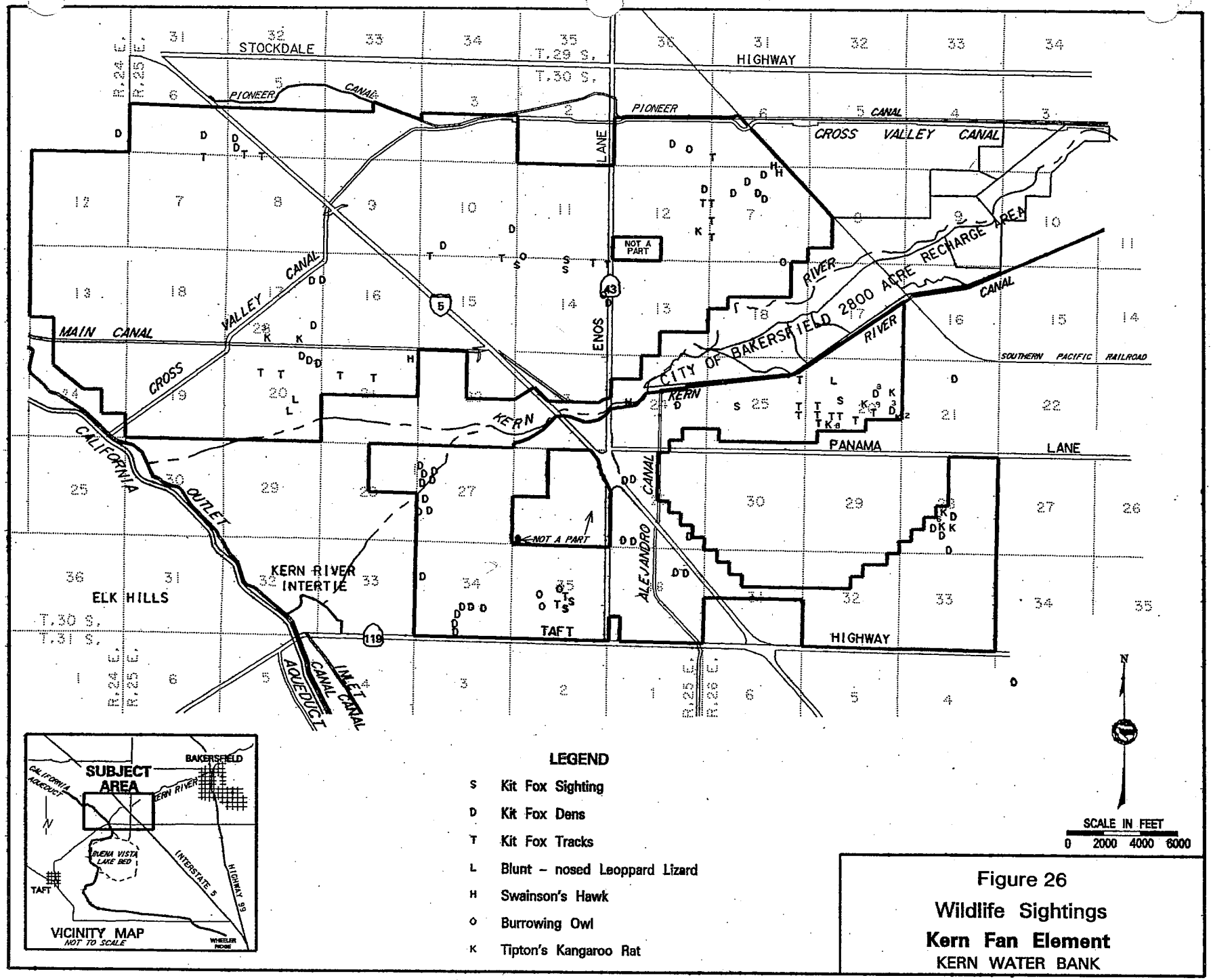



Figure 26
Wildlife Sightings
**Kern Fan Element**
KERN WATER BANK

Blunt-nosed leopard lizard surveys were conducted concurrently with walking transect surveys for other species on KFE property. The optimum period for blunt-nosed leopard lizard activity is from mid-April to mid-June when air temperatures are between 22° C and 36° C (71° F and 97° F). An attempt was made to conduct surveys between 9:00 a.m. and 2:00 p.m. and when air temperatures were in the optimum range. The blunt-nosed leopard lizard was sighted on three occasions on the property. Two individuals were observed near the Main Canal Ponds and the third was observed within the area proposed for the South River Ponds. All sightings occurred before the end of July and were in concrete ditches or other supply canals in fallow agricultural fields. Additional ground searches will be required during the next field season to determine the distribution and use of the KFE property by blunt-nosed leopard lizards.

## Birds

Avian survey techniques included riparian transects, raptor routes, variable circular plots, and incidental birding (random searches for avian species). These were conducted to establish avian activity and potential impacts associated with pond construction on KFE property. Avian surveys were conducted from June through October 1990. A total of 48 species of birds were recorded during the studies. Four are species of special status, including State or federally listed threatened, endangered, candidates for listing, or species of special concern. Common species observed include: mourning dove, western meadowlark, red-winged blackbird, and house sparrow.

Two 2-km (1.25 miles) riparian transects were established along the Kern River. Surveys were conducted twice a month during July and August and four times a month during September and October. The two riparian transects were surveyed a total of 27 times. Observation time along each transect was about 1½ hours.

Four raptor routes, ranging from 10.5 to 17.2 km (6.5 to 10.7 miles) were established and surveyed 93 times from June through November. Routes were driven at about 16 kmph (10 mph) for about one hour. The turkey vulture *(Carthartes aura)* was the most commonly observed species. The northern harrier *(Circus cyaneus)*, a species of special concern, and the Swainson's hawk *(Buteo swainsoni)*, State listed threatened, also were observed.

Variable circular plots (VCPs) were conducted from August through October in areas of native vegetation, fallow fields, and cultivated areas on KFE property. Stations were randomly chosen throughout the sampled area. A total of 119 VCPs were completed with a census time at each station ranging from 10 to 15 minutes depending upon the habitat type. No VCPs were conducted in riparian areas because these areas were surveyed via the riparian transects. Birds were identified either visually or by call. The distance to each sighting was estimated.

Incidental birding activity during the course of the study resulted in several sightings of listed and candidate species as well as other common species within the project area.

## Mammals

Field survey techniques for small mammals inventoried on KFE property included: spotlighting, scent stations and track pads, small mammal live trapping, walking transects, and other incidental observations. Preliminary search of records included a search of records from DFG's Natural Di-

versity Data Base, review of information received from the Wildlife Habitat Relationship System for Kern County, and interviews with local persons (farmers and petroleum workers). The primary focus of the surveys was potential activity by sensitive species. The study team amassed 26 non-consecutive nights of spotlight surveys and about 1,000 small mammal trap nights. All observations were recorded by Universal Transverse Mercator (UTM) coordinate number for inclusion in DWR's Geographic Information System database.

Spotlight surveys were conducted on 32 occasions from the end of June and October, using two hand-held 400,000 (or greater) candle-power spotlights from vehicles driven at 16 kmph (10 mph) or less. When eye shine or animal movement was detected, binoculars were used to confirm the species or identify eye shine color. Mammals observed during spotlight surveys were mapped on a 7.5-minute USGS quad map. Twelve species of mammals were recorded during 48 hours of total observation time. Fourteen San Joaquin kit foxes were sighted. One badger, a species of special concern, also was sighted.

Scent stations and track pads were surveyed from mid-July through October on KFE property. Track pads were spaced at approximately 200 m (650 feet) intervals on or near roads within the study areas. A total of 428 scent stations and track pads were established along eight transects. Scent stations were placed on level ground that was cleared of vegetation. Stations were baited in the late afternoon and checked the following morning. Although many of the areas identified for pond construction are currently being farmed, substantial small mammal activity was recorded. Track pads recorded visits by kit foxes, coyotes, badgers, striped skunks, lagomorphs, small mammals, and birds (Table 5). Of the 428 scent stations on the KFE property, 135 registered San Joaquin kit fox activity. Sixty-seven percent of the kit fox activity was recorded in the area of the proposed South River Ponds (Table 6).

Small mammal live trapping, using Sherman live traps, was used to sample the rodent population on the property. A total of 953 trap nights of effort were expended from July through October. Most of the effort was concentrated within proposed recharge ponding basins. The Tipton's kangaroo rat, a State and federal endangered species, was captured on 22 occasions.

Walking transects, covering over 1,200 acres in and adjacent to areas targeted for construction of First Stage facilities, were used specifically to record San Joaquin kit fox, giant kangaroo rat, and San Joaquin antelope ground squirrel activity. Transects were walked between 15 and 50 meters (50 – 164 feet) apart. Observations of San Joaquin antelope ground squirrel, giant kangaroo rat, and kit fox were recorded. All kit fox dens, known and potential, were identified and recorded by UTM number. A total of 73 potential kit fox dens (simple and complex), including one natal den, have been identified and mapped. Figure 27 shows the area surveyed by walking transects and Table 7 denotes kit fox den locations with respect to recharge pond sites. Twenty-one dens were located within potential ponding basins. Eleven dens were found within the proposed South River Ponds site.

**Table 5. Track Pad Results**

| | |
|---|---|
| Small mammal | 190 |
| San Joaquin kit fox | 135 |
| *Dipodomys* sp. | 42 |
| Lagommorph | 34 |
| Coyote | 33 |
| Bird | 14 |
| Striped skunk | 10 |
| Badger | 9 |
| **Total** | **442** |

**Table 6. Kit Fox Activity**

| Ponding Basin | # of Stations Recording Kit Fox Tracks | Percent |
|---|---|---|
| Stockdale Highway Ponds | 7 | 5.2 |
| Sunset Ranch Ponds | 8 | 5.9 |
| Mail Canal Ponds | 4 | 3.0 |
| South River Ponds | 91 | 67.4 |
| Outside ponding basins | 25 | 18.5 |
| **Total** | **135** | **100.0** |

**Table 7. Kit Fox Den Locations**

| Location | Potential Complex | Potential Simple | Known Complex | Known Simple | Natal | Total |
|---|---|---|---|---|---|---|
| Stockdale Highway Ponds | 2 | — | 1 | — | — | 3 |
| Sunset Ranch Ponds | 1 | 1 | — | 1 | — | 3 |
| Main Canal Ponds | 2 | — | 1 | 1 | — | 4 |
| South River Ponds | 3 | 8 | — | — | — | 11 |
| Other | 23 | 26 | 2 | — | 1 | 52 |
| **Total** | **31** | **35** | **4** | **2** | **1** | **73** |

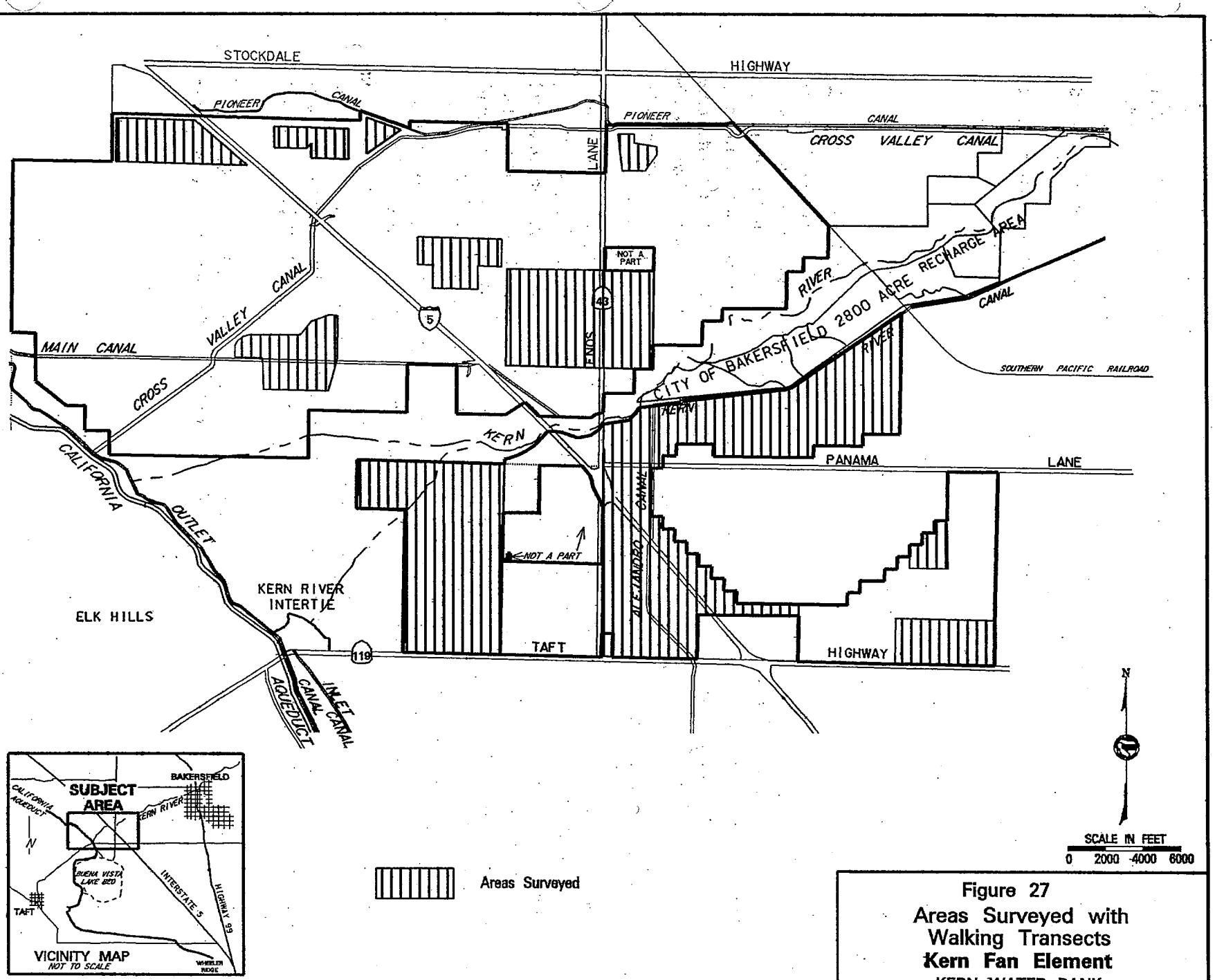



Figure 27
Areas Surveyed with Walking Transects
**Kern Fan Element**
KERN WATER BANK

The comments received on the Notice of Preparation for the First Stage Kern Fan Element program conveyed interest regarding potential effects on water quality, wildlife, and wildlife habitat. The Department of Water Resources agreed, as part of the KFE program discussed in the 1986 EIR, to include a plan in the KFE development that would allow lands not actively used for recharge to revert to native habitat. Vegetation and wildlife studies are currently being conducted to inventory the status of species on the KFE property. The results of these studies and the mitigation requirements, if any, will be identified in the Final SEIR. Since some of the issues raised in the Notice of Preparation were not evaluated in the Program EIR (1986), those issues will be examined in this document.

## Impacts of Construction and Operation Activities on Sensitive Wildlife

Construction activities for the KFE program may cause potentially significant effects to the federal and State endangered blunt-nosed leopard lizard and Tipton's kangaroo rat, and the federally listed endangered, State listed threatened San Joaquin kit fox. The First Stage program will require about 1,300 acres. A small portion (about 350 acres) of the disturbance will be confined to existing recharge basins, roads, or other facilities, while the remainder will consist of disturbance to areas that were previously in agriculture. Some of these lands have been fallow for quite some time and, with the re-establishment of native vegetation, these areas are now being reoccupied by wildlife. The presence of the blunt-nosed leopard lizard, San Joaquin kit fox, or the Tipton's kangaroo rat may potentially result in a take during the construction of the KFE facilities.

Sensitive species may be impacted and an incidental take may result from the operation of the KFE facilities. DWR recognizes this potential conflict exists. However, since lands not actively used for recharge will be allowed to revert to native habitat, potential impacts can be minimized by improving or restoring previously farmed areas to native habitat before lands needed for the KFE facilities are disturbed. By creating the new habitat first and relocating sensitive species to these areas, adverse impacts will be minimized and a net benefit will result for wildlife.

DWR will also design and implement a habitat conservation plan with the objective of restoring, preserving, and enhancing additional areas of native habitat to support threatened, endangered, and sensitive species. This conservation plan will be designed to meet the requirements of the federal and State endangered species acts and will comply with CEQA and NEPA. DWR will cooperate with the City and County of Bakersfield and other agencies to maintain a continuous open corridor between the foothills and the San Joaquin Valley for wildlife by restoring and/or preserving as much land as feasible on the KFE property.

DWR is also pursuing a Section 10(a) permit under the Federal Endangered Species Act. This section allows a take of a protected species if the party causing the take possesses a valid permit.

# LAND USE

Most of the land acquired for the KFE is currently leased for agriculture. The Memorandum of Understanding between DWR and KCWA provides for the phase out of all agricultural production on KFE property by the end of 1993. The MOU also states that local benefits be allowed on the KFE, whether for ground water recharge or other use. Until agriculture is phased out, DWR is required to minimize potential problems with weeds and dust on the KFE property. After ultimate build out of KFE facilities, some form of initially managed vegetation will be needed throughout the property.

Formal planning for the land conversion is under way, and several potential uses are being considered. While some lands will be used for additional recharge ponds and facilities for completion of the KFE or for local recharge projects, other lands may be converted to wildlife habitat to mitigate for damage caused by the KFE facilities, other SWP facilities and programs, or possibly for mitigation of local development. Other possibilities include waterfowl and upland habitat development, other wildlife enhancement, and/or recreation development. Until a final land use plan is adopted, the deliberate establishment of habitat for threatened and endangered species in areas where future project facilities or other potentially conflicting uses are envisioned should be minimized.

## Potential Near-Term and Future Land Uses

***Ground Water Recharge and Conveyance Facilities.*** The proposed First Stage consists of about 1,300 acres of recharge ponds and conveyance canals as shown earlier in Figure 3 and detailed in Table 8. Preliminary delineation of corridors reserved for alternative Second Stage KFE conveyance facilities and areas reserved for Second Stage recharge ponds is shown in Figure 28. These reserved areas are based on a conceptual-level selection of the alternatives likely to be evaluated during the preliminary design of the Second Stage facilities. As such, it is expected that the actual land needs for the Second Stage facilities will be somewhat less than the total requirements estimated on the basis of Figure 28. The primary conveyance facility corridors are based on likely alternatives for the State Canal. The area of the primary conveyance facility corridors is estimated to be about 500 acres. The total length of primary corridors is about 14 miles, with an assumed width of 300 feet. The secondary corridors are based on the needs for smaller future recharge and extraction canals, pipelines, and project roadways similar to the First Stage facilities. A considerable portion of these corridors overlie existing farm roads and parts of the Pioneer Canal System. The area of the secondary conveyance facilities corridors is estimated to be 850 acres. The total length of secondary corridors is about 47 miles, with an assumed width of 150 feet. The reserves for future recharge ponds are based on the areas with the best potential recharge rates. Second Stage ponds will be selected from within the areas shown. The total area of the recharge pond reserves is about 1,900 acres.

**Table 8. First Stage Facilities: Construction Corridors And Pond Areas**

| Item | CONSTRUCTION CORRIDOR Length | CONSTRUCTION CORRIDOR Width | DISTURBED AREA Acres |
|---|---|---|---|
| Recharge Facilities | | | |
| Existing recharge ponds | — | — | 320 |
| New First Stage recharge ponds | — | — | 790 |
| New supply canals | 3.4 | 60 | 25 |
| Rehabilitation of existing laterals | 6.2 | 40 | 30 |
| New Main Canal intake | 1 | 100 | 12 |
| Extraction Facilities | | | |
| Buried pipeline | 7.3 | 30 | 27 |
| Concrete-lines canals | 6.6 | 45 | 36 |
| Pumpback facility | — | — | 3 |
| Roadways | | | |
| Primary roads | 8 | 50 | 48 |
| Secondary roads | 3.7 | 30 | 13 |
| TOTAL | | | 1,291 |
| ROUNDED TOTAL | | | 1,300 |

* Assumes that 6.7 miles of 14.7–mile total length of the primary road system are improvements to existing field roads.

KCWA proposes to use up to 4,000 acres of the KFE property for additional recharge ponds and conveyance facilities to capture and recharge flood flows in the Kern River that presently enter the California Aqueduct via the Kern River Intertie structure.

***Agricultural Leases.*** All agricultural leases on KFE property will be phased out by the end of 1993 in accordance with terms of the 1987 MOU with KCWA. About 15,400 acres are currently leased on the property. Some non–irrigated crops may be allowed past 1993. However, the continuation of any agricultural leases involving ground water use after 1993 would require approval by, and a contract amendment with, KCWA.

In some areas, where the ground water is presently contaminated by agricultural chemicals, the best means of treatment may be use of the extracted water for irrigation. If ongoing investigations support this concept, irrigated agriculture could be continued in selected areas of the KFE as a means of correcting water quality problems.

***Wildlife, Native Vegetation and Recreation.*** As part of the process for planning future additions to SWP conservation storage, DWR has examined opportunities for expanding recreation and fish and wildlife benefits.

Implementation of the KFE will provide opportunities for the development of areas to benefit wildlife and recreation. To achieve these benefits, DWR has initiated a local land use planning process (discussed in the following section) to develop specific areas of the property for wildlife habitat, recreation, and recharge of local flood waters. The land use process emphasizes providing

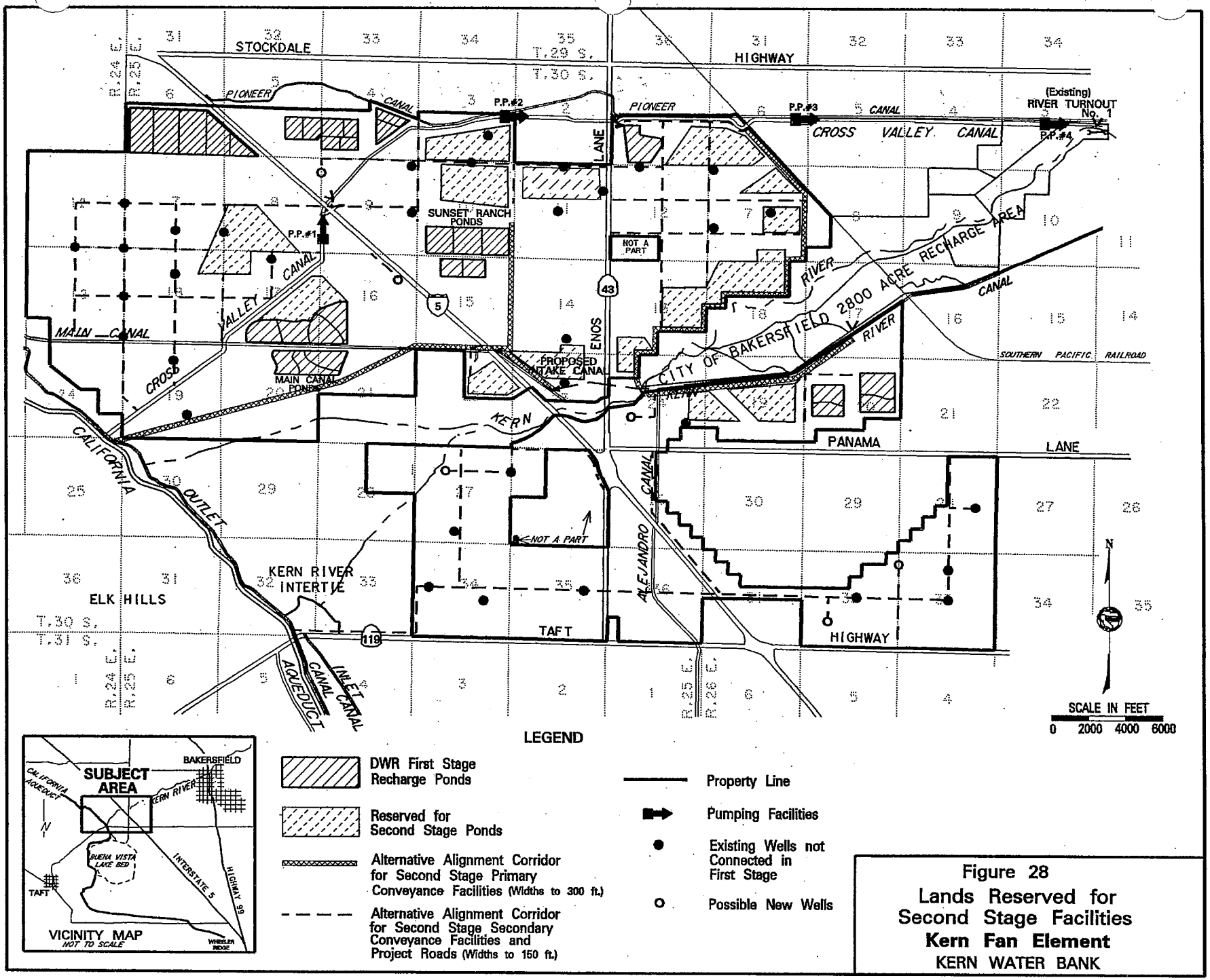



Figure 28
Lands Reserved for Second Stage Facilities
**Kern Fan Element**
KERN WATER BANK

as much multiple use of the land as possible. For example, lands developed for local flood water spreading will also be retained as wildlife habitat in some form (conceivably a mix of upland habitat and intermittent wetlands).

While development of the KFE provides some unique opportunities for recreation and wildlife, there are some limitations. The August 1988 purchase agreement with Tenneco West, Inc., requires that land farmed at the time of sale will continue to be farmed or tilled for five years following purchase unless used for recharge and extraction facilities. Therefore, development of areas for wildlife are precluded through the end of 1993 on much of the property. Other limitations include: (1) potential interference with future water recharge areas; (2) potential conflicts with adjacent land uses (such as oil fields and farming); and (3) limitations related to physical factors such as location, geography, access to water, etc.

The planning for the KFE is being designed to accommodate the staged development of facilities as well as the five-year phase-out of agriculture. There is a possibility that some wildlife and recreation uses can be developed before 1993. However, it may require an amendment to the purchase agreement with ARCO (successor to Tenneco), to allow other uses to be developed in the near term. Specific plans for wildlife and recreation will be developed as part of the land use planning process.

Some land use changes, such as the development of riparian areas near some of the First Stage ponds, can occur prior to 1993. The specific design of these areas will be developed in cooperation with DFG and wildlife groups. Some of the recharge ponds can conceivably be operated and used as wetland habitat for waterfowl and other wildlife. This is the case with areas that may be developed for local recharge, which would not be flooded with great frequency. DWR intends to restore to native habitat those areas that are not proposed for potential recharge facilities. If feasible, DWR plans to create upland and wetland habitat mitigation areas contiguous to existing native wildlife habitat on the property, as well as within the Kern River corridor. This will help minimize the creation of habitat "islands" that limit the movement of wildlife and constrain habitat-carrying capacity for some wildlife species. DWR proposes to use as much of this native habitat as possible as a mitigation "bank account" to be used to offset mitigation required for ongoing or other proposed SWP facilities and programs. While the matter of mitigation banking is unresolved, the concept is expected to be developed over the next few years. DWR will work closely with DFG and the U.S. Fish and Wildlife Service in this matter, and will consult in the development of such areas with KCWA and the SWP water contractors.

Recreation activities currently being considered on the KFE property include bicycle and equestrian trails along Enos Lane and the proposed Kern River Parkway. Currently, a small parcel on the property is used by the Brittany Club, Inc. for dog training and trials. Dog trials are expected to continue and may be expanded. The Tule Elk Reserve, operated by the State Department of Parks and Recreation, is adjacent to a portion of the western boundary of the KFE property. A suggestion has been made to DWR that the western portion of the KFE property be opened for elk grazing during part of the year. DWR will consult with the Department of Parks and Recreation to determine the feasibility of this proposal.

***Mineral Extraction.*** ARCO owns the mineral rights to much of the KFE property. Existing petroleum extraction activities will likely continue, and additional extraction facilities will probably be constructed on the property in the future. DWR is proposing to provide specific easements for oil

and gas extraction platforms and access roads to limit future intrusion and impact on restored and existing native habitat, while not constraining mineral rights. Seismic and drilling exploration for minerals will continue. DWR will propose agreements with mineral rights holders to minimize disturbance associated with mineral exploration.

## Land Use Advisory Committee

In June 1990, DWR and KCWA held an initial public meeting to discuss current and future land uses on KFE property and to establish a land use advisory committee. Participants at the meeting included individuals representing the general public; local, State, and federal public groups; and private organizations. Interests included recreation, agriculture, mineral extraction, native habitat and wildlife conservation, water resources and local utilities.

The purpose of the initial meeting was to assess public interest in participating in a land use advisory process to formulate a long-term land use plan for the KFE property. In subsequent meetings, DWR assembled subcommittees representing the above interests as well as a general land use advisory committee to help formulate a long-term land use plan. Guidelines were developed and presented to the subcommittees for consideration in the development of compatible land use activities. This committee will consider recommendations from the subcommittees and submit final recommendations to DWR. The guidelines include the following provisions:

- All "reasonable" land use activities will be considered.
- DWR recharge ponds come first in time and use.
- Lands with the greatest recharge potential will be considered for recharge before other uses.
- No native habitat will be disturbed to create wetland habitat.
- Recharge and waterfowl ponds do not necessarily have to be combined.
- Mineral extraction on the property will continue.
- Wherever possible, DWR will select multiple use plans over single use options.

Since the interest in establishing areas of specific land use activities on the KFE site is greater than the area available, DWR, with recommendations from the land use committee, expects to combine compatible uses where possible. For example, compatible uses could include native habitat restoration, recreation, and tule elk access. Another potential combination could be recharge ponds and intermittent wetland habitat creation. DWR expects that the land use advisory process will extend into 1994 and be tied to the phase-out of irrigated agriculture and the construction of recharge and extraction facilities.

## Geographic Information System

One tool being used to assist in the land use planning process is DWR's KWB Geographic Information System (GIS). A GIS is an electronic mapping/relational data base system which allows the user to illustrate multiple layers of landscape attributes such as soil type, vegetation cover, hydrography, and land use.

Currently, DWR has the following layers of information:

- Hydrography
- Land Use
- Native Vegetation Cover
- Recharge Pond Locations
- Land Ownership
- Pipeline and Utility Corridors
- Water Well Locations

Ultimately, DWR will have additional layers, including wildlife habitat and siting information, Metropolitan Bakersfield Habitat Conservation Plan conservation areas, Elk Hills Naval Petroleum Reserve information, soil type and infiltration rates, ground water levels, water quality patterns, and cropping patterns.

As the land use planning process progresses, the GIS is expected to be a valuable tool in helping identify compatible and conflicting land uses over the entire KFE property. In addition, the GIS will help show the spatial relationships between the proposed elements of the KWB and the connections between habitat conservation areas. The GIS will allow the Land Use Advisory Committee and DWR to explore different land use combinations and optimize the siting of recharge and extraction facilities and other proposed land uses.

# Chapter 4. SIGNIFICANT EFFECTS OF THE PROPOSED PROJECT AND MITIGATION

This chapter sets forth those potentially significant environmental effects of implementing the proposed project and discusses the mitigation measures that would reduce adverse impacts to less than significant effects. Table 9 summarizes the potentially significant effects of the project and mitigation measures that will be used to reduce impacts to less than significant.

## WILDLIFE

Adverse impacts to wildlife species could result from the construction of recharge ponds or other facilities proposed for the KFE lands. Several sensitive species are known to occur within the project area. Although proposed recharge areas have been located on currently farmed or recently farmed lands, some sensitive wildlife species have become established in these disturbed areas. Since there is the potential for project activities to result in the take of sensitive species, DWR initiated informal consultation with the Department of Fish and Game (DFG) and the U.S. Fish and Wildlife Service (USFWS), pursuant to the endangered species acts. DWR will obtain the appropriate clearances and permits to construct and operate KFE without jeopardizing the continued survival of sensitive species or habitat.

Before construction begins, DWR will retain technical specialists to survey the area to determine site-specific conditions that can be avoided, including San Joaquin kit fox burrows, Tipton's kangaroo rat precincts, and potential blunt-nosed leopard lizard habitat. Any potential dens found will be flagged. If a potential den is considered unavoidable, adequate surveys will be conducted to determine whether the den is occupied. If the den is occupied, it should be surveyed by night spotlighting during the pupping season (April through June) to determine if it is a natal den. Natal dens will be avoided. Nonnatal dens will be excavated, if unavoidable, by a qualified biologist before construction to ensure that no kit foxes are present. Mitigation measures for disturbance to kit fox habitat or dens by construction activities can be minimized by timing the activities and by creating substitute habitat with selective borrowing of the embankment materials required for the recharge pond and canal embankments.

Additional information is needed to determine whether the blunt-nosed leopard lizard and Tipton's kangaroo rat will be impacted by the construction and/or operation of the KFE. If future studies conclude that impacts to these species are likely, DWR will institute appropriate mitigation measures for these species and prepare a habitat conservation plan covering all DWR activities on the KFE property, in accordance with DFG and FWS mitigation policy and in compliance with A.B. 3180 (Mitigation Monitoring). Any impacts associated with the construction and operation of the KFE will be mitigated by converting lands acquired as part of the KFE from agriculture to other uses beneficial to wildlife. These conversions are expected to compensate for negative impacts caused by construction activities.

## Table 9. Significant Effects And Mitigation Measures

| Impact Category | Impact | Mitigation |
|---|---|---|
| Ground water quality | A number of pesticides have been used that have a potential to contaminate ground water throughout that portion of the property that was farmed. | An exploration and sampling program is being conducted at each recharge site to determine whether contaminants are present. A water quality monitoring program has been implem ented to detect potential contaminants in the ground water.<br><br>To the extent that pesticide problems are identified, solutions are expected to include on-site and/or nearby use of water from the affected well(s) for irrigation to the extent that water quality is suitable for that purpose, until the problem no longer exists. In addition, there is sufficient flexibility in the number and capacity of First Stage extraction wells to shift pumping away from a problem area. |
| | Petroleum hydrocarbon contamination from pipelines represents the most significant ground water quality threat on the KFE property. Contaminated areas on the property could limit use of some portions of the property for recharge and restrict extractions from some areas if ground water is contaminated. | All recharge basins constructed during the First Stage will be set back 500 feet from identified pipelines.<br><br>The ongoing water quality monitoring program includes petroleum hydrocarbons. Any identiied problem areas will be isolated from use and corrected. Operational flexibility with alternate wells and recharge basins will preserve the water supply benefits of the project. |
| Ground water level depression | Ground water levels will drop during extraction. Localized impacts could occur to wells immediately adjacent to the KFE property in some areas. | To the extent that adverse water level impacts occur, pumping can be shifted to other First Stage extraction wells elsewhere on the property or curtailed. Alternately, arrangements could be made to interconnect potentially affected wells with the KFE extraction system to compensate the users for adverse impacts. |
| Local mounding | Ground water mounding is expected in the immediate area of the recharge basins. Prolonged KFE and local recharge (including local recharge in areas adjacent to or near the KFE property) has the remote potential to impact a limited acreage of tree and vine crops in the area. | Water levels will be monitored via a regional ground water monitoring network developed by DWR. To the extent that any projected interference problems are associated with KFE recharge, such potential problems will be handled by shifting KFE recharge to other areas and/or reducing recharge. Nearby extraction wells could also be used if needed to depress water levels to avoid impacts. |

**Table 9. Significant Effects And Mitigation Measures (continued)**

| Impact Category | Impact | Mitigation |
|---|---|---|
| Delta impacts | The potential exists for winter-run salmon to be impacted by additional Delta diversions required for the KFE. During dry, critical, and below-normal precipitation years, some winter-run juveniles may be entrained at the Banks Pumping Plant during the January-through-March period. The potential adverse impact on winter-run salmon smolts as a result of increased Delta diversions for the KFE is not possible to quantify. The KFE will result in diversions that will add only 1.5 percent to the total diversions. By itself, this would not be significant; however, due to the winter run is now considered endangered and any impact potentially could be significant. | An interagency winter-run team has been established to develop a recovery plan for the winter-run salmon in the upper Sacramento River. A joint federal/State recovery team has also been established pursuant to the endangered species acts. In addition, DWR is proceeding with informal consultation with NMFS and DFG on the potential impacts of proposed Delta facilities and changes in south-of-the-Delta storage projects on winter-run salmon. If the recovery team and consultation process conclude that SWP pumping causes a take, DWR will work to provide the appropriate mitigation and/or measures to minimize adverse effects. If an incidental take permit is required and appropriate, DWR will work with the respective regulatory agency in compliance with the State or federal Endangered Species Act. |
| Wildlife | Construction activities may cause potentially significant effects to the blunt-nosed leopard lizard, Tipton's kangaroo rat, and the San Joaquin kit fox, all threatened or endangered species. | Before construction begins, a qualified biologist will be retained to survey the area and determine site-specific conditions that should be avoided. Potential kit fox dens will be excavated or avoided. Buffer areas will be required around potential and natal dens. Speed limits will be posted during breeding season to restrict vehicle traffic. DWR will initiate formal consultation with DFG and FWS, pursuant to the endangered species acts. DWR will prepare a conservation plan so future activities at KFE do not result in a take of endangered species. |

# GROUND WATER LEVEL AND QUALITY MONITORING PROGRAM

The proposed ground water banking project will require extensive monitoring to identify possible adverse water level and quality impacts and to provide data for design of optimal project operations. DWR has installed monitoring wells on the KFE property and in the 2,800-Acre Recharge Area (Figure 29), and will construct a regional monitoring well network and additional monitoring wells on KFE property in the future (Figure 30). Characteristics of the existing monitoring wells are given in Table 10.

## 2,800-Acre Area Network

DWR, the City of Bakersfield, and KCWA have installed clusters of multiple completion monitoring wells at ten locations within the 2,800-Acre Recharge Area. These wells provide discrete water

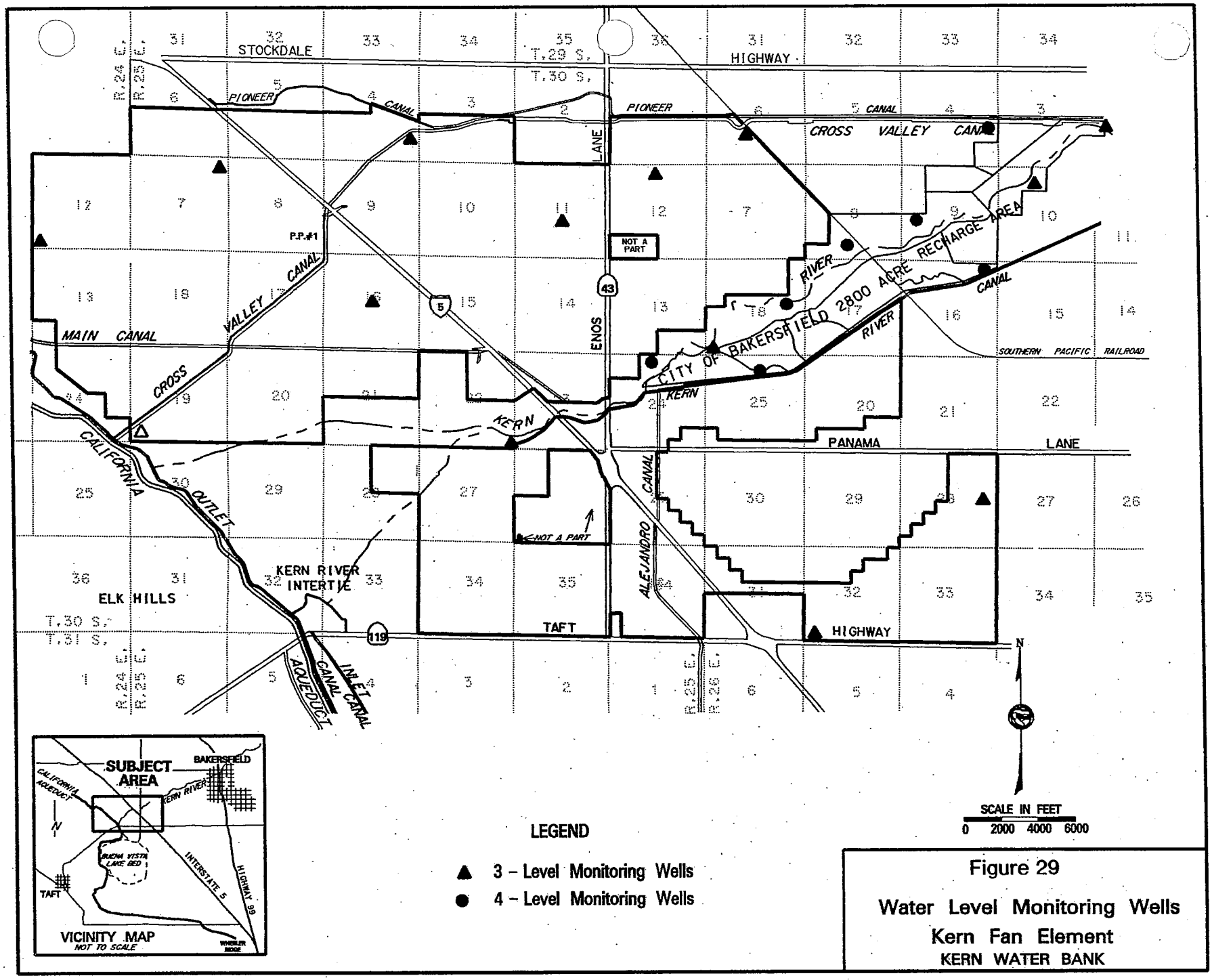



Figure 29

Water Level Monitoring Wells
Kern Fan Element
KERN WATER BANK

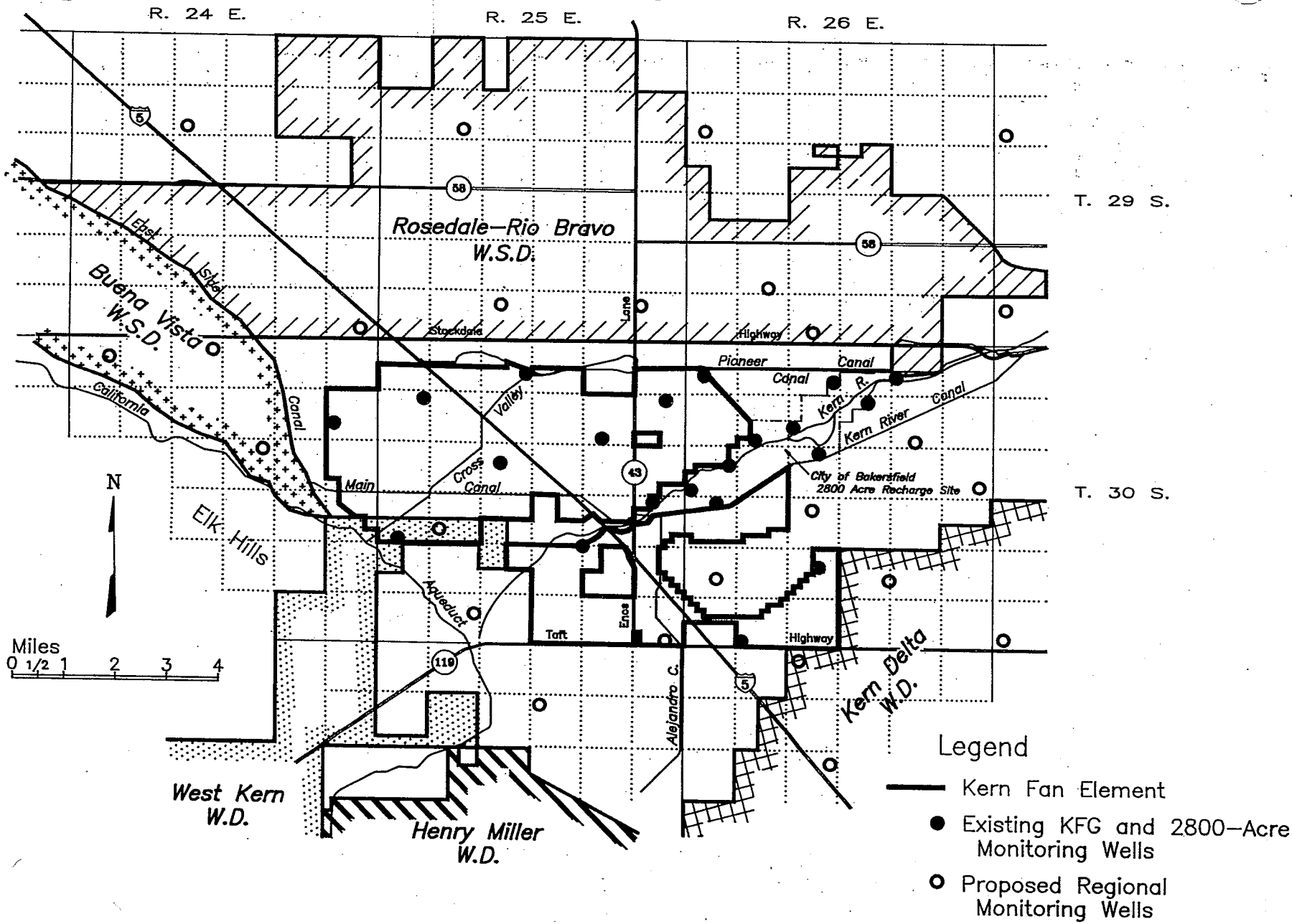



**Figure 30 KERN FAN ELEMENT PROPOSED REGIONAL MONITORING WELL NETWORK**

**Table 10**

**Characteristics of Existing Monitoring Wells**

| Cluster Number | State Well Number | Depth (feet) | Measuring Point Elevation (feet) | Perforated Interval (feet) | Casing Diameter (inches) |
|---|---|---|---|---|---|
| 1 | 30S/26E-02M01M | 250 | 354.63 | 150-250 | 4 |
| | 30S/26E-02M02M | 110 | 354.81 | 85-110 | 2 |
| | 30S/26E-02M03M | 50 | 354.41 | 40-50 | 2 |
| 2 | 30S/26E-10C01M | 250 | 350.05 | 150-250 | 4 |
| | 30S/26E-10C02M | 100 | 350.45 | 75-100 | 2 |
| | 30S/26E-10C03M | 50 | 349.34 | 30-50 | 2 |
| 3 | 30S/26E-09M04M | 700 | 345.34 | 620-700 | 6 |
| | 30S/26E-09M01M | 250 | 345.21 | 150-250 | 4 |
| | 30S/26E-09M02M | 100 | 344.97 | 80-100 | 2 |
| | 30S/26E-09M03M | 50 | 345.03 | 30-50 | 2 |
| 4 | 30S/26E-08P04M | 680 | 334.96 | 600-680 | 6 |
| | 30S/26E-08P01M | 250 | 334.86 | 150-250 | 4 |
| | 30S/26E-08P02M | 100 | 334.80 | 80-100 | 2 |
| | 30S/26E-08P03M | 40 | 334.36 | 30-40 | 2 |
| 5 | 30S/26E-18H04M | 540 | 333.23 | 440-540 | 6 |
| | 30S/26E-18H01M | 250 | 333.33 | 150-250 | 4 |
| | 30S/26E-18H02M | 100 | 333.32 | 75-100 | 2 |
| | 30S/26E-18H03M | 50 | 333.30 | 30-50 | 2 |
| 6 | 30S/26E-18N01M | 250 | 328.91 | 150-250 | 4 |
| | 30S/26E-18N02M | 90 | 329.03 | 70-90 | 2 |
| | 30S/26E-18N03M | 60 | 328.68 | 35-60 | 2 |
| 7 | 30S/25E-24C04M | 525 | 322.90 | 445-525 | 6 |
| | 30S/25E-24C01M | 250 | 322.90 | 150-250 | 4 |
| | 30S/25E-24C02M | 90 | 322.95 | 70-90 | 2 |
| | 30S/25E-24C03M | 65 | 322.38 | 55-65 | 2 |
| 8 | 30S/26E-04J03M | 650 | 350.84 | 560-650 | 6 |
| | 30S/26E-04J02M | 375 | 351.08 | 223-375 | 6 |
| | 30S/26E-04J01M | 150 | 351.32 | 100-150 | 6 |
| | 30S/26E-04J04M | 65 | 350.97 | 45-65 | 2 |
| 9 | 30S/26E-16B03M | 660 | 346.36 | 530-660 | 6 |
| | 30S/26E-16B02M | 390 | 346.77 | 330-390 | 6 |
| | 30S/26E-16B01M | 250 | 347.28 | 140-250 | 6 |
| | 30S/26E-16B04M | 50 | 345.14 | 35-50 | 2 |
| 10 | 30S/26E-19B03M | 590 | 326.91 | 500-590 | 6 |
| | 30S/26E-19B02M | 390 | 327.38 | 300-390 | 6 |
| | 30S/26E-19B01M | 220 | 327.86 | 120-220 | 6 |
| | 30S/26E-19B04M | 45 | 325.66 | 35-45 | 2 |

**Table 10 (cont.)**

**Characteristics of Existing Monitoring Wells**

| Cluster Number | State Well Number | Depth (feet) | Measuring Point Elevation (feet) | Perforated Interval (feet) | Casing Diameter (inches) |
|---|---|---|---|---|---|
| 11 | 30S/25E-04J02M | 250 | 313.01 | 190-250 | 6 |
| | 30S/25E-04J03M | 455 | 312.50 | 345-455 | 6 |
| | 30S/25E-04J04M | 625 | 312.00 | 565-625 | 6 |
| 12 | 30S/26E-06L01M | 270 | 333.32 | 210-270 | 6 |
| | 30S/26E-06L02M | 536 | 332.73 | 360-536 | 6 |
| | 30S/26E-06L03M | 620 | 332.23 | 585-620 | 6 |
| 13 | 30S/25E-19N02M | 120 | 296.77 | 90-120 | 6 |
| | 30S/25E-19N03M | 230 | 296.31 | 190-230 | 6 |
| | 30S/25E-19N04M | 385 | 295.78 | 310-385 | 6 |
| 14 | 30S/25E-22R01M | 125 | 312.03 | 80-125 | 6 |
| | 30S/25E-22R02M | 300 | 311.54 | 235-300 | 6 |
| | 30S/25E-22R03M | 460 | 311.00 | 380-460 | 6 |
| 15 | 30S/26E-32N01M | 330 | 314.12 | 210-330 | 6 |
| | 30S/26E-32N02M | 440 | 313.67 | 390-440 | 6 |
| | 30S/26E-32N03M | 610 | 313.17 | 570-610 | 6 |
| 16 | 30S/25E-12B02M | 250 | 325.5± | 150-250 | 6 |
| | 30S/25E-12B03M | 500 | 325.0± | 360-500 | 6 |
| | 30S/25E-12B04M | 690 | 324.5± | 590-690 | 6 |
| 17 | 30S/25E-11P01M | 210 | 319.2± | 150-210 | 6 |
| | 30S/25E-11P02M | 470 | 318.7± | 330-470 | 6 |
| | 30S/25E-11P03M | 570 | 318.2± | 520-570 | 6 |
| 18 | 30S/25E-16L01M | 345 | 305.5± | 285-345 | 6 |
| | 30S/25E-16L02M | 555 | 305.0± | 515-555 | 6 |
| | 30S/25E-16L03M | 690 | 304.5± | 645-690 | 6 |
| 19 | 30S/26E-28J01M | 220 | 336.5± | 120-220 | 6 |
| | 30S/26E-28J02M | 330 | 336.0± | 280-330 | 6 |
| | 30S/26E-28J03M | 615 | 335.5± | 540-615 | 6 |
| 20 | 30S/25E-07A01M | 290 | 299.5± | 220-290 | 6 |
| | 30S/25E-07A02M | 470 | 299.0± | 420-470 | 6 |
| | 30S/25E-07A03M | 620 | 298.5± | 530-620 | 6 |
| 21 | 30S/24E-13D01M | 250 | 289.5± | 150-250 | 6 |
| | 30S/24E-13D02M | 360 | 289.0± | 320-360 | 6 |
| | 30S/24E-13D03M | 650 | 288.5± | 520-650 | 6 |

level information on three or four zones in the aquifer system below the recharge area. They will provide reliable water level information for calibration of the ground water model being developed for the project, and provide information on aquifer properties as they respond to pumping from nearby extraction wells. In addition, the monitoring network is designed to identify the extent of vertical connection within the aquifer system by examining response to both pumping and recharge and to identify the effects of shallow, low-permeability materials on sustained recharge rates. In the future, it may be desirable to supplement the existing network with a series of very shallow (20 feet) monitoring wells to better define possible mounding effects.

Water levels have been measured in the monitoring wells on a monthly basis since 1988. In 1989, measurements were taken monthly during the nonirrigation season and biweekly during the irrigation season. Monitoring will be performed more often to evaluate the effects of extraction wells and recharge effects. Water levels are measured nearly continuously at four cluster locations by electronic data loggers.

No recharge has occurred in the 2,800–Acre Recharge Area since the monitoring well network was installed. As of October 1990, all the very shallow wells (about 50 feet deep) and most of the shallow wells (about 100 feet deep) were above the water table, and water levels continue to decline. Water quality sampling on a quarterly basis is being conducted in the deep monitoring wells and multiple completion wells constructed by DWR. Water quality monitoring is discussed in a later section of this chapter.

## KFE Monitoring Network

***Multiple Completion Wells.*** DWR has installed a network of 11 multiple completion monitoring wells on KFE property. The primary purpose of this network is to evaluate the response of different aquifer zones to pumping and recharge stresses. Some of the data collected will be used to calibrate and verify the ground water model being developed. The network is also suitable for identifying water level fluctuations near the project boundaries that may affect adjacent water districts. The water levels in these wells are measured at the same frequency as those in the 2,800–Acre Recharge Area. In addition, DWR will also continue to take spring and fall water level measurements on KFE production wells. To provide information on the amount and distribution of pumping on KFE property and its impact on the aquifer system, DWR has installed flow meters on all active production wells on the property. These meters are read monthly during the nonirrigation season and bimonthly during irrigation.

A secondary purpose of the monitoring wells is to provide ground water quality information on the property. In accordance with this objective, many of the wells were constructed downgradient from potential sources of water quality degradation. The wells are initially being sampled quarterly for a wide range of water quality parameters. Suitable production wells are sampled annually. The results of the sampling are discussed in the water quality section of this chapter.

***Water Quality Monitoring Wells.*** In addition to the network of multiple completion monitoring wells, DWR will construct a series of wells designed specifically for water quality monitoring of potential sources of contamination. Figure 31 shows the tentative location of 11 water quality monitoring wells. All the wells, except for that located in Section 36, are placed to detect contamination from oil field operations. The monitoring well in Section 36 is designed to monitor possible adverse impacts of the sewage disposal operation to the south. The design of an effective water

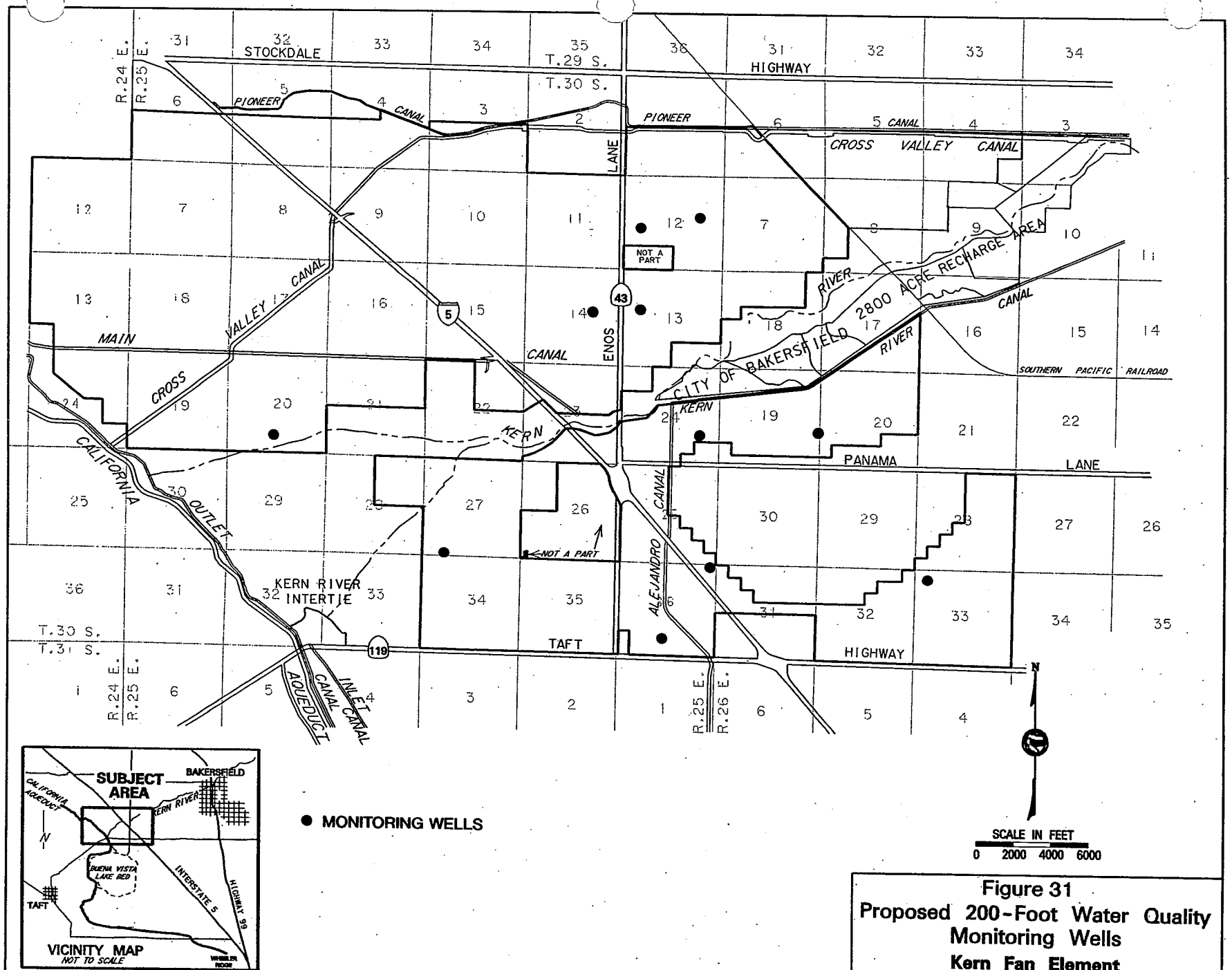



**Figure 31**
**Proposed 200-Foot Water Quality Monitoring Wells**
**Kern Fan Element**
**KERN WATER BANK**

quality monitoring program in the oil fields is complicated by the dispersed nature of the threat, and by the need to obtain samples from near the water table (while water levels may fluctuate 200 feet or more over the life of the project). DWR has contracted for technical assistance in evaluating the monitoring options, as well as in identifying a suitable monitoring network. A monitoring network, when combined with an active surveillance and enforcement program, will help identify and minimize the potential for contamination from oil field operations.

A small area of DWR's property near Tupman (Figure 32) contains water with elevated TDS. This area of poor quality water is about 1.5 miles west of the West Kern Water District well field. West Kern Water District is concerned with the potential of movement for this water during project operation. DWR has delineated the areal extent of the poor quality water and will install monitoring wells to determine whether it is affected by project operation. DWR will characterize the extent of poor quality water to the south in the North Coles Levee Oil Field and, if needed, install additional monitoring wells in this area.

***Recharge Pond Monitoring.*** A monitoring program will be developed for each recharge site, and a system of monitoring wells will be constructed there. The purpose of these wells is to evaluate the movement of water and mounding effects in response to recharge and to assist in regulating recharge operations. Mounding, should it develop, will adversely affect percolation rates and will require changes in pond operation to maximize recharge.

These wells will also serve to monitor water quality in the recharge areas and identify any problems resulting from leaching of contaminants during recharge. The number, location, and design of the monitoring wells will be defined following detailed exploration of the pond sites. During pond operation, inflow to individual ponds and water levels will be measured daily to determine percolation rate trends and to identify the need for pond rehabilitation.

***Subsidence Monitoring.*** Land subsidence is not expected to be a significant problem. However, the occurrence of subsidence in nearby areas and the large drawdowns expected during project operation indicate that there is some potential for this to occur. DWR will develop a leveling network throughout the KFE property on which global positioning satellite technology will be used to establish elevations every five years to identify any subsidence, whether resulting from project operation, oil and gas production, or tectonic movement. To assist in differentiating the cause of any detected subsidence, an extensometer will be installed to detect compaction resulting from water level declines.

## Regional Monitoring Network

Regional ground water impacts of the KFE operations are of concern to adjacent water districts and water users. In addition, regional water level information is needed to calibrate the ground water model being developed for use in evaluating and refining project operations. To address these needs, DWR has designed a regional monitoring well network as illustrated earlier in Figure 30. The network will consist of 25 multiple completion monitoring wells. Initially, most will be double completion wells that will monitor the unconfined upper aquifer and the deep (below mapped depths of the Corcoran Clay) confined aquifer. Those wells close to KFE property may be constructed as triple completion wells depending on the results of logging during drilling.

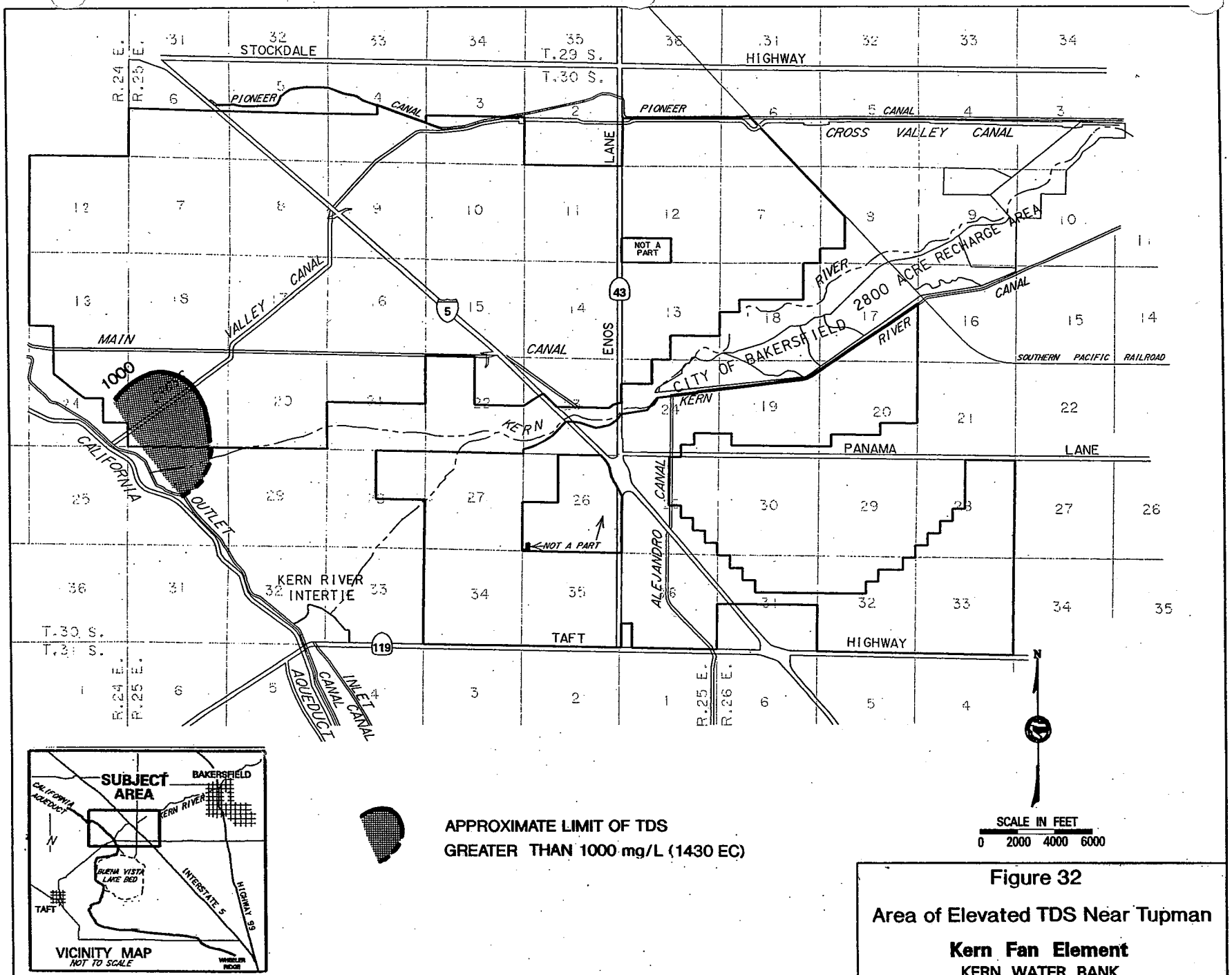



Figure 32

Area of Elevated TDS Near Tupman

**Kern Fan Element**

KERN WATER BANK

The network will consist of two components. The first is a series of wells near the boundaries of a KFE property but located within the adjacent districts. These wells will form a continuation of the networks already installed on KFE property and in the 2,800-Acre Recharge Area. The entire network will be generally orthogonal to the Kern River and spaced on an approximate two-mile grid. The primary purpose of the first series of wells is to identify any water level impacts of project operations on adjacent districts, while providing reliable water level information for model calibration. The second series of wells will be used to define the boundary conditions for the model.

Those monitoring wells located in the southern portion of the Buena Vista Water Storage District and near the Henry Miller Water District well field were designed to monitor the possible incursion of poor quality westside water into the ground water basin. The KFE regional monitoring well network is intended to form the nucleus of a larger network that will include monitoring for any local elements that are developed.

## Water Quality Monitoring Program

The historical land use of DWR's property, coupled with the expected use of much of the water as a source of public drinking water, necessitates an extensive water quality monitoring program. Ground water quality monitoring will focus on two areas. The first is monitoring of general minerals, selected minor elements, and selected physical parameters to give a general picture of ground water quality and any changes resulting from project operation. These data will also be useful in investigating the hydraulic characteristics of the project area. The second area of water quality monitoring will focus on toxic organics, primarily pesticide residues and petroleum hydrocarbons, and other parameters that may be of special concern.

A two-phase approach to monitoring has been adopted. The monitoring program discussed in this EIR can be considered detection monitoring. The program is designed to identify and alert project operators to water quality problems. When a water quality problem is identified, a more intensive corrective action monitoring program would be developed that would include additional exploratory drilling, monitoring well construction, sample collection and analysis. All sample collection and analysis would be conducted according to established protocols because of potential use in enforcement actions. The elements of the detection monitoring program are described below.

General minerals, minor elements, and physical parameters will be monitored quarterly for one year in all monitoring wells. The parameters being measured are shown in Table 15. After one year, sampling will be discontinued for those minor elements that have not been detected, unless a MCL or action level has been proposed or established for that constituent. Quarterly monitoring will continue through the first complete recharge and drawdown cycle during project operation, at which time it will be reduced to an annual basis.

Pesticides listed in Title 22 (Drinking Water Standards), those listed in Tables 12, 13, and 14, and Rank One and Two pesticides with a history of use on KFE property (Table 15) will be sampled quarterly. After one year, sampling for pesticides with established MCLs or action levels will be reduced to semiannually, and sampling for pesticides for which no MCLs or action levels have been established will be reduced to annually. After the first year of monitoring, sampling will be discontinued in the deep zone of each monitoring well, unless pesticide residues have been detected in the shallow or intermediate zones. The semiannual and annual monitoring will continue

through the first project fill cycle following the cessation of farming on the property. At that time, monitoring for pesticide residues that have not been detected will be reduced to a three-year cycle. Pesticide monitoring in those wells in the "interior" of DWR's property may be eliminated after the first three-year cycle, if residues are not detected. However, monitoring of the shallow and intermediate levels in monitoring wells on the perimeter of DWR's property (except those in the 2,800-Acre Recharge Area) will continue for the life of the project. This is necessary to detect movement of pesticide residues onto DWR's property from adjacent farmland. An initial sampling of all production wells for pesticide residues will be conducted and will be repeated on a three-year cycle through the first complete recharge cycle after farming on the property has ended. Confirmed detection of a pesticide residue will trigger a shift to corrective action monitoring and result in the involvement of the appropriate regulatory agency.

Pesticide application records are incomplete; therefore an element of risk is inherent in the above approach. Further, two pesticides (toxaphene and EPTC) have been detected that are neither Rank One nor Rank Two. However, the proposed approach is a reasonable balancing of cost versus the possibility of failing to recognize a contaminant.

**Table 11. Standard Minerals, Minor Elements, and Physical Parameters Analyzed in the First Stage Monitoring Program**

| | | |
|---|---|---|
| Sodium | Total Dissolved Solids | Zinc |
| Magnesium | Electrical Conductivity | Barium |
| Chloride | pH | Lead |
| Boron | Uranium | Silver |
| Copper | Germanium | Alkalinity |
| Manganese | Lithium | Total Hardness |
| Arsenic | Calcium | Temperature |
| Cadmium | Potassium | Total Chromium |
| Mercury | Nitrate | Vanadium |
| Molybdenum | Sulfate | Nickel |
| | Iron | |

## Table 12. Chlorinated Organic Pesticides

| | |
|---|---|
| Diuron | Endosulfan I |
| BHC, alpha | Dieldrin |
| Chlorpropham | DDE |
| Dichloran | Endrin |
| Simazine | Endosulfan II |
| BHC, gamma | Endrin Aldehyde |
| BHC, beta | DDD |
| Atrazine | Endosulfan Sulfate |
| PCNB | DDT |
| BHC, delta | Methoxychlor |
| Chlorothalonil | Dicofol |
| Alachlor | Toxaphene |
| Heptachlor | PCB-1016 |
| Thiobencarb | PCB-1221 |
| Chlorpyrifos | PCB-1232 |
| Aldrin | PCB-1242 |
| DCPA | PCB-1248 |
| Captan | PCB-1254 |
| Heptachlor Epoxide | PCB-1260 |
| Chlordane | |

## Table 13. Organic Phosphorus Pesticides

| | |
|---|---|
| Mevinphos | Parathion |
| Demeton | Methidathion |
| Naled | Profenofos |
| Phorate | s,s,s-Tributyl Phosphorothrithioate (DEF) |
| Dimethoate | Ethion |
| Diazinon | Carbophenothion (Trithion) |
| Disulfoton | Phosmet |
| Methyl Parathion | Phosalone |
| Malathion | Azinphosmethyl |
| Chlorpyrifos | |

## Table 14. Carbamate Pesticides

| | |
|---|---|
| Aldicarb Sulfoxide | Aldicarb |
| Aldicarb Sulfone | Carbofuran |
| Oxamyl | Carebaryl |
| Methomyl | 1-Naphtol |
| 3-hydroxycarbfuran | Methiocarb |

**Table 15. Rank One and Rank Two Pesticides With a History of Use of KFE Property**

| Rank One | Rank Two |
|---|---|
| Aldicarb | Dimethoate |
| Atrazine | Disulfoton |
| Carbofuran | Endothall |
| 1,2,-Dichloropropane | Parathion |
| EDB | Phorate |
| | Prometryn |

The potential for contamination by petroleum hydrocarbons will continue throughout the life of the project. The parameters to be measured are listed in Table 16. In addition, screening will be done for total petroleum hydrocarbons and for base/neutral/acid parameters quarterly for one year. Sampling will be done quarterly at all wells specifically installed to monitor oil field operations. Semiannual sampling will be conducted in the upper and middle zones of the multiple completion monitoring wells located downgradient of the oil fields. If significant contamination by petroleum hydrocarbons is detected, further exploration and testing will be conducted to identify the source, characterize the extent of contamination, and identify a responsible party for cleanup. Production wells will be screened for petroleum-related parameters on the same schedule as for pesticide residues.

**Table 16. Purgeable Organics**

| | |
|---|---|
| Vinyl Chloride | Bromodichloromethane |
| Trichlorofluoromethane | Toluene |
| 1,1,2-Trichlorotrifluoroethane | 1,1,2-Trichloroethane |
| 1,1-Dichloroethylene | Tetrachloroethylene |
| trans-1,2-Dichloroethylene | Dibromochloromethane |
| 1,1-Dichloroethane | Ethylene dibromide |
| cis-1,2-Dichloroethylene | Chlorobenzene |
| Chloroform | Ethylbenzene |
| 1,1,1-Trichloroethane | Xylene(s) |
| Carbon tetrachloride | Bromoform |
| Benzene | 1,3-Dichlorobenzene |
| 1,2-Dichloroethane | 1,4-Dichlorobenzene |
| Trichloroethylene | 1,2-Dichlorobenzene |
| 1,2-Dichloropropane | 1,2-Dibromo-3-chloropropane |

Two facilities merit special attention for analysis of petroleum-related organics. These are the property leased to Grayson Services, Inc. and the area near the old carbon black plant. (The site is currently being used by Hondo Chemical to produce soil amendments). A monitoring well will be constructed on the Grayson lease and sampled quarterly for volatile and semivolatile organics. Chemicals used or present on the lease will be inventoried and monitoring parameters adjusted as appropriate. The situation at the carbon black plant is somewhat different in that it is located off DWR's property and normally will be downgradient. However, during extraction periods, the gradient may be reversed. The shallow and intermediate zones of monitoring well 30/26-6L will be sampled annually for volatile, semivolatile organics, and polynuclear aromatic hydrocarbons.

(DWR's well numbering system is explained in Chapter III of the KFE Feasibility Report.) During periods of gradient reversal, sampling will be performed quarterly.

Radiological screening will be conducted at all monitoring wells. Quarterly sampling will be done for gross alpha and gross beta for one year and one-time sampling will be conducted for tritium. Sampling for gross alpha and gross beta will continue on a four-year cycle. Samples with gross alpha values exceeding five picocuries per liter or gross beta values exceeding 50 picocuries per liter will undergo further analysis to determine the source of radiation.

***Produced Water Quality Monitoring.*** A water quality monitoring program will be implemented at those points where extracted water returns to a public water supply source (California Aqueduct, CVC). An initial set of samples and then quarterly samples will be collected when extraction occurs. Analysis will include general minerals and minor elements, organic compounds for which MCLs and action levels have been established, other components exclusive of microbiological parameters for which MCLs or action levels have been established, and organic compounds detected by the KFE ground water monitoring program. Water quality criteria for water returning to a source of public water supply should require that water not exceed an MCL. If a detected chemical exceeds 0.6 times an MCL or action level, corrective action will be triggered to prevent further increases in concentration, identify sources of contamination, and implement appropriate cleanup/treatment programs. This will provide reasonable assurance that MCLs will not be violated during project operation. During extraction, monthly sampling should be conducted for wells extracting water from areas of known contamination and analyzed for the constituents of concern. This is to provide early warning of possible violations of the MCLs and allow timely corrective action.

***Recharge Water Quality Monitoring.*** Water quality will be monitored at the turnout for each source water used for recharge. Electrical conductivity will be measured continuously and used to establish a predictive relationship for the total dissolved solids and sodium content of the water. Turbidity and suspended solids will be measured monthly, except when local floodflows are recharged or local inflow occurs to the California Aqueduct. At those times, measurements will be taken daily. Criteria will be developed to establish turbidity and/or suspended solids standards to be met before recharge is permitted. Nutrients (nitrogen and phosphorus) will be measured monthly during recharge. Recharge ponds are to be observed weekly by a trained professional to assess their biological condition. During the first recharge cycle at each pond site, monthly monitoring will be performed for all Rank One and Rank Two pesticides and total petroleum hydrocarbons. Subsequent water quality monitoring would be limited to those compounds identified during the first recharge cycle.

The proposed project may result in the loss of agricultural uses of the land. Permanent changes in land use also would occur where wells, canals, pumps, and other facilities are needed. Resources and energy required to manufacture the steel and concrete used for construction and long-term operation of the proposed project would be irretrievably committed.

# Chapter 5. CUMULATIVE EFFECTS AND RELATED PROJECTS

This chapter discusses the cumulative effects on the environment that could potentially result from implementing the proposed project in conjunction with other existing and/or proposed programs that are related to the proposed project. This discussion also examines the use of local water supplies on the Kern Fan Element property, assuming implementation of the First Stage.

## GROUND WATER RECHARGE/EXTRACTION PROJECTS

There are several proposed or recently implemented projects that are related to the project proposed in this Draft SEIR. These are the La Hacienda Program, the Goose Lake Slough property purchase, the 1990 Demonstration Programs, the 1987 Advance Storage Program, and proposed local elements to the Kern Water Bank. These projects are discussed below.

### La Hacienda Program

The La Hacienda program involves the purchase of 98,000 acre-feet of water that is currently stored in the Kern County Ground Water Basin. This stored water resulted from the recharge of Kern River flood flows over the past ten years in the City of Bakersfield's 2,800-Acre Recharge Area by Olcese Water District. Olcese Water District has the contractual right to sell any stored water excess to its long-term needs to La Hacienda, Inc., who in turn desires to sell this water to DWR. DWR wants to purchase this water to deliver it within Kern County as part of SWP deliveries in future dry years, when SWP water supplies are low.

This water would be extracted by wells on the KFE property, and conveyed to the CVC and Alejandro Canal for exchange with water that would otherwise be diverted from the SWP California Aqueduct. DWR will renovate 23 wells on the property, and construct necessary pipelines and canals to convey the extracted water to the local canals for exchange. This program is targeted at extracting water as soon as April 1991, in case the current prolonged dry cycle continues.

At the time this report was being prepared, DWR was negotiating a purchase agreement with La Hacienda, Inc. DWR was also negotiating a separate operating agreement with KCWA whereby KCWA would operate and maintain the extraction facilities to implement this program.

## Goose Lake Slough

In March 1990, DWR purchased some 550 acres of farmland along Goose Lake Slough, 2 miles north of the northeast corner of the KFE property and within the boundaries of Rosedale–Rio Bravo Water Storage District. This property was purchased due to its good potential for recharge. Some of the property has been used for recharge in the past.

The property was originally purchased to complement the recharge activities on the KFE property. While the property could be developed as part of the KFE, it is more likely to be developed as part of the local element proposed by Rosedale–Rio Bravo Water Storage District. No specific plans have yet been developed beyond the reconnaissance–level study recently completed by Rosedale–Rio Bravo.

## 1990 Demonstration Programs

During 1990 DWR entered into agreements with KCWA and five local water districts to transfer some 150,000 acre–feet of water in the SWP's San Luis Reservoir to storage in the Kern County Ground Water Basin. All of this water was delivered for direct irrigation use, and used to offset a like amount of ground water pumping that would otherwise have occurred. This water will be recovered for SWP use by exchanging it in future years with surface water deliveries that would otherwise be made from the California Aqueduct. The exchanges are made possible through payment by DWR for additional use of local irrigation wells. In general, most of the water would be exchanged over a two year period, when conditions are dry enough to require such exchange.

## 1987 Advance Storage Program

By agreement dated January 12, 1987, DWR and KCWA agreed to recharge a limited amount of water during 1987, as a trial recharge program in advance of implementing the Kern Water Bank. This program is known as the 1987 Advance Storage Program. During January and February 1987, DWR recharged some 7,379 AF in the City of Bakersfield's 2,800–Acre Recharge Area.

It is anticipated that this water will count toward initial storage for the First Stage.

## KCWA 1990 Emergency Extraction Program

During the spring of 1990, KCWA became aware that water supplies available to its member water districts would be significantly below normal. This was based on the 50 percent reduction in SWP supplies, as well as substantially reduced water supplies from other sources. At that time, KCWA began discussions with DWR concerning eventual use of a number of irrigation wells on the KFE property to meet local water needs.

As the year progressed, water supply conditions in Kern County became very serious. The KCWA Board declared a drought emergency. At KCWA's request, DWR allowed KCWA to use seven of the wells on the property to extract water which had previously been recharged in the City of Bakersfield's 2,800–acre Recharge Area.

Implementation of this program resulted in some upgrades to the wells, and construction of several buried pipelines to transport the extracted water to the CVC. The seven wells will also be used as part of the La Hacienda Program, as well as the First Stage of the KFE.

## Local Elements

The Kern Water Bank ultimately will consist of a series of "elements," geographically separate ground water storage and extraction projects that would be operationally integrated. The Kern Fan Element will be followed by local elements developed with a number of water districts in Kern County. At present, reconnaissance-level studies are underway or have been completed with Cawelo Water District, KCWA Improvement District No. 4, Kern Delta Water District, Rosedale-Rio Bravo Water Storage District, and Buena Vista Water Storage District in a combined program with West Kern Water District.

DWR, KCWA and Semitropic Water Storage District are completing a feasibility study for the proposed Semitropic Local Element. This program would consist of expanding the capacity of existing surface water distribution facilities to serve farms that presently irrigate with ground water. This expansion of the existing conjunctive water use facilities within Semitropic will allow the Local Element to store water by providing extra surface water in wetter years in lieu of pumping ground water. Likewise, additional pumping of ground water in dry years could be exchanged for surface water otherwise delivered to Semitropic's service area from the California Aqueduct. The program will be implemented through completion of a separate feasibility report and California Environmental Quality Act process, expected by mid-1991.

## Local Uses of the Kern Fan Element

KCWA wants to develop up to 4,000 acres of the KFE property for local recharge and extraction. Provision for local use is included in the 1987 MOU between DWR and KCWA. The MOU states:

> The Contract will provide for local uses of the land acquired for the Kern Fan Element, and will provide that facilities constructed for use by the SWP be available for recharge and extraction of local water by the agency. Such local uses shall be defined and compensation, therefore shall be provided for in the Contract.

Local uses are divided into two general categories: (1) local recharge of Kern River and other local flood flows and (2) recharge of other water in non-flood years. Kern County water interests would like to keep as much of the local flood flows as possible in Kern County for recharge into the ground water basin. The second category includes SWP entitlement water which would be delivered to KCWA pursuant to Article 12(d) of the water supply contract with DWR. This water is "makeup" for entitlement water not delivered in previous years due to SWP delivery deficiencies. The second category also includes other sources of water in non-flood years. There is no definitive means of charting the amount of such water that may be available in any year. DWR anticipates that such recharge will be allowed, provided that it does not interfere with the SWP recharge and extraction program.

## Potential Impacts From Local Recharge

The general guideline used in studies and discussions to date is that local recharge of Kern River floodwaters will have precedence over SWP recharge, and that SWP recharge will have precedence over recharge of other local supplies. Recharge of flood flows was considered and discussed in the 1987 Preliminary Technical Report, and assumed to take precedence when flows in the Kern River would otherwise cause water to go through the Kern River Intertie into the California Aqueduct.

To the extent that KCWA makes use of KFE recharge ponds, no wildlife disruption is expected beyond what is considered in this Draft SEIR. However, KCWA envisions spreading flood flows over large areas of land outside the confined SWP recharge basins, by constructing shallow embankments following land contours (similar to construction of basins used for growing rice). In May 1990, KCWA staff developed a map showing areas that could potentially be used for this purpose as soon as January 1991, subject to availability of flood flows.

Since that time, KCWA staff have directed their efforts at planning for and designing turnouts from the Cross Valley Canal and the Kern River, which would serve the dual purposes of providing capacity to divert flood flows to the property as well as diverting SWP water from the California Aqueduct for recharge. No site-specific work has yet been conducted for proposed local recharge areas in sufficient detail to include in this Draft SEIR. The general areas proposed by KCWA for near-term local recharge are shown in Figure 33. Basic selection criteria used by KCWA to lay out proposed recharge areas were:

- Recently farmed lands, but currently not leased.
- Lands in non-native vegetation.
- No lands would be developed initially in the northeast portion of the property, due to potential ground water quality problems in this area.
- To the extent practicable, lands adjacent to First Stage recharge ponds would be used.
- Lands easily served by the CVC, the Pioneer and/or James Canals lateral systems, the Kern River, or a combination of such facilities.

While no site-specific plans have been completed, some general observations can be made concerning potential environmental impacts of construction and operation of proposed local water spreading areas. KCWA will need to deal with similar mitigation issues that DWR will address in development of recharge areas. This will include provisions for wildlife that may be using the property that would be disrupted during construction and operation. As discussed elsewhere in this Draft SEIR, these provisions are likely to include relocation of habitat to other areas of the KFE property.

However, the KCWA proposed large-scale recharge areas have the potential advantage of being developed as combined upland/wetlands wildlife habitat as well as recharge areas, due to the proposed method of water confinement on the property, the resulting shallow water depths, and the expected duration of flooding. Such lands could be allowed to revert to native habitat, with provisions for intermittent flooding such as occurred prior to agricultural development of this portion of the San Joaquin Valley. Possibilities could include development of higher elevation "islands", travel corridors to the Kern River, and development of some areas as managed wetland habitat. It is expected that such development will require close coordination among KCWA, DWR, the Department of Fish and Game, U.S. Fish and Wildlife Service, the City and County planning departments, and regional wildlife groups. There is the potential to develop a program whereby significant quantities of local floodwaters could be recharged while providing meaningful wildlife benefits.

In addition, there are some water quality considerations that may affect the configuration of KCWA proposed recharge areas. A number of oil pipelines go through the KFE property, gener-

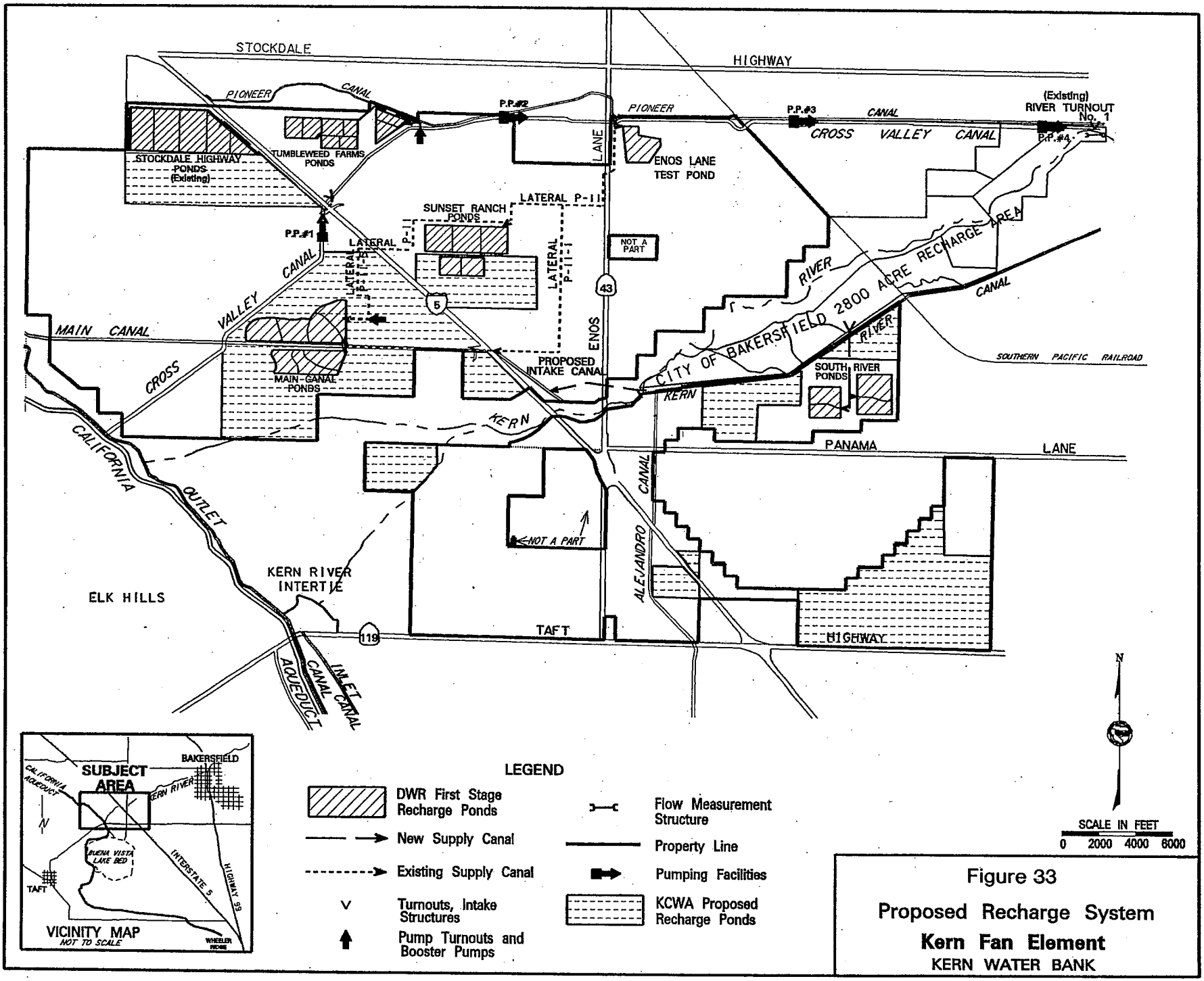



Figure 33

Proposed Recharge System

**Kern Fan Element**

KERN WATER BANK

ally buried 2–3 feet below ground level. There is substantial evidence that such pipelines can leak, and that relatively small leaks can go undetected for some period of time. To the extent that oil leaks exist or are likely to occur over time, DWR has taken the position that recharge areas be set back some distance from known pipelines. The same would be true for KCWA recharge areas. The local recharge areas shown in Figure 33 do not take into account this limitation. In addition, there is evidence that in some areas of the property, ground water contamination from historically used pesticides has occurred. DWR has undertaken an extensive soil and water monitoring program to address this issue, and has modified recharge and extraction plans accordingly. The same concerns need to be addressed in sufficient detail for proposed local recharge areas.

## Potential Impacts From Local Extraction

KCWA has proposed an aggressive local recharge program on the property, although no specific information has been completed concerning either frequency or magnitude of expected recharge. In any case, any local recharge will only result in an increase in ground water levels, which is a benefit to ground water pumping in the region. It is only the extraction that could potentially cause negative impacts to ground water levels.

It is assumed that SWP use of extraction wells on the KFE property will have first priority. Based on water supply benefit studies, SWP use will generally be in the very dry years. However, it is possible that local use could include wells that are not developed specifically for the First Stage. Therefore, opportunities will exist for local use. Such use would presumably begin once a local storage account has been developed that would accompany an extraction program.

The frequency, magnitude, and other conditions for local use are speculative at this time, since such details have not yet been developed. It is likely that this matter will be addressed only in general terms in the initial operating agreement between DWR and KCWA, and that specific use provisions will be developed over time, as the need arises and as specific plans are developed. Consequently, potential environmental impacts resulting from local use of extraction facilities will need to be addressed in a subsequent environmental study conducted by KCWA.

# OTHER RELATED PROJECTS

## Metropolitan Bakersfield Habitat Conservation Plan (MBHCP)

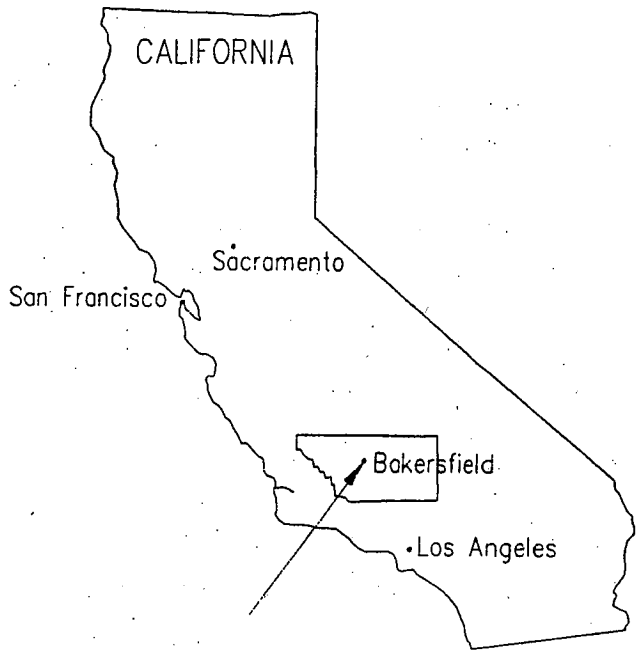
The MBHCP provides an opportunity to link KFE conservation lands with future habitat conservation areas proposed by the MBHCP Steering Committee. The "primary goal of the MBHCP is to acquire, preserve, and enhance native habitats which support endangered and sensitive species, while allowing urban development to proceed. . ."

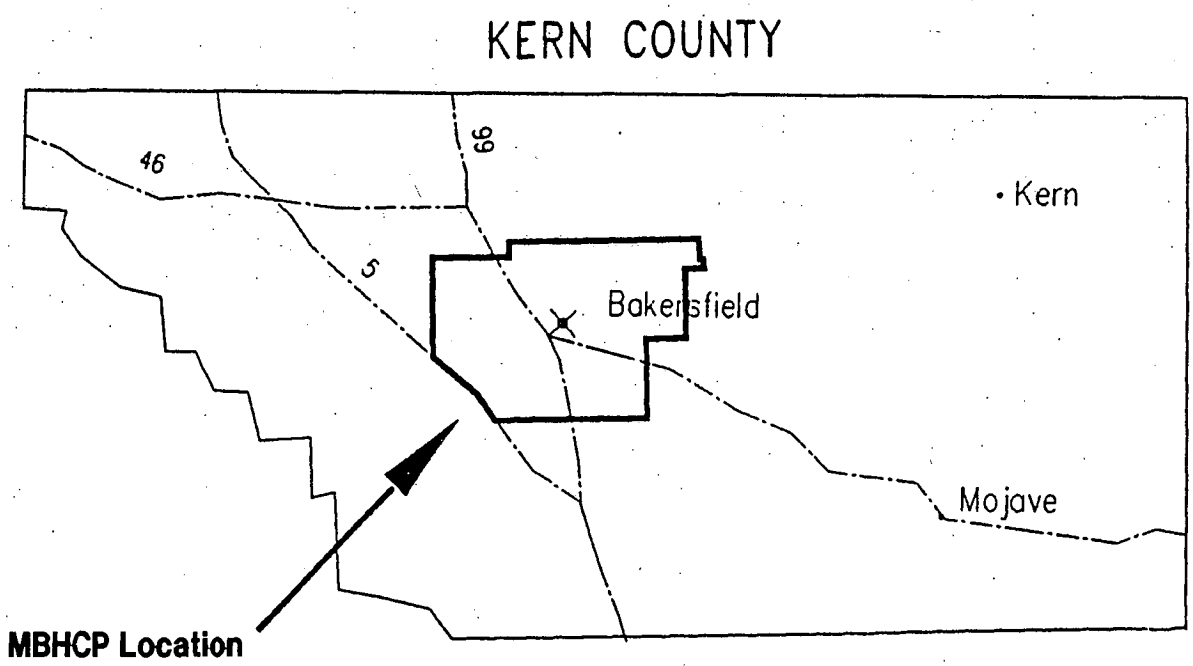
Conflicts between urban development and native species prompted the City of Bakersfield and Kern County to formulate a habitat conservation plan. Figure 34 shows the location of potential local preserve acquisition areas associated with the MBHCP.

Potential exists for local agencies to use MBHCP funds for restoration/enhancement of KFE lands to meet local habitat conservation requirements. Of course, issues of ownership, management, and meshing of multiple use goals will have to be resolved before any conservation plans are implemented on the KFE property.

Figure 34

**METROPOLITAN BAKERSFIELD HABITAT CONSERVATION PLAN**



## ARCO Oil and Gas Company – Bakersfield Arch Seismic Surveys

ARCO is proposing to conduct seismic oil exploration surveys on about 50 square miles of land west of Bakersfield (Figure 35). The Bakersfield Arch seismic survey area encompasses much of the KFE property. Consultants (Quad Consultants) to ARCO performed a preliminary (Phase I) reconnaissance study to identify and map potentially sensitive plant and wildlife habitat throughout the proposed seismic survey area. A second phase will include a survey for rare, threatened, and endangered plant and animal species and related habitat on and adjacent to the seismic survey area.

ARCO is requesting an information consultation with the USFWS and feels that it can avoid any significant negative impacts associated with its seismic surveys, including incidental take of threatened or endangered species that might be located in the project area.

DWR hopes to share wildlife habitat information and cooperate with ARCO in an effort to identify and preserve sensitive plants and animals, particularly on the KFE. In addition, DWR hopes to maintain direct cooperation through the land use advisory process and involve ARCO in any habitat conservation efforts.

## Central Valley Habitat Joint Venture

The Central Valley Habitat Joint Venture is the California component of the North American Waterfowl Management Plan.

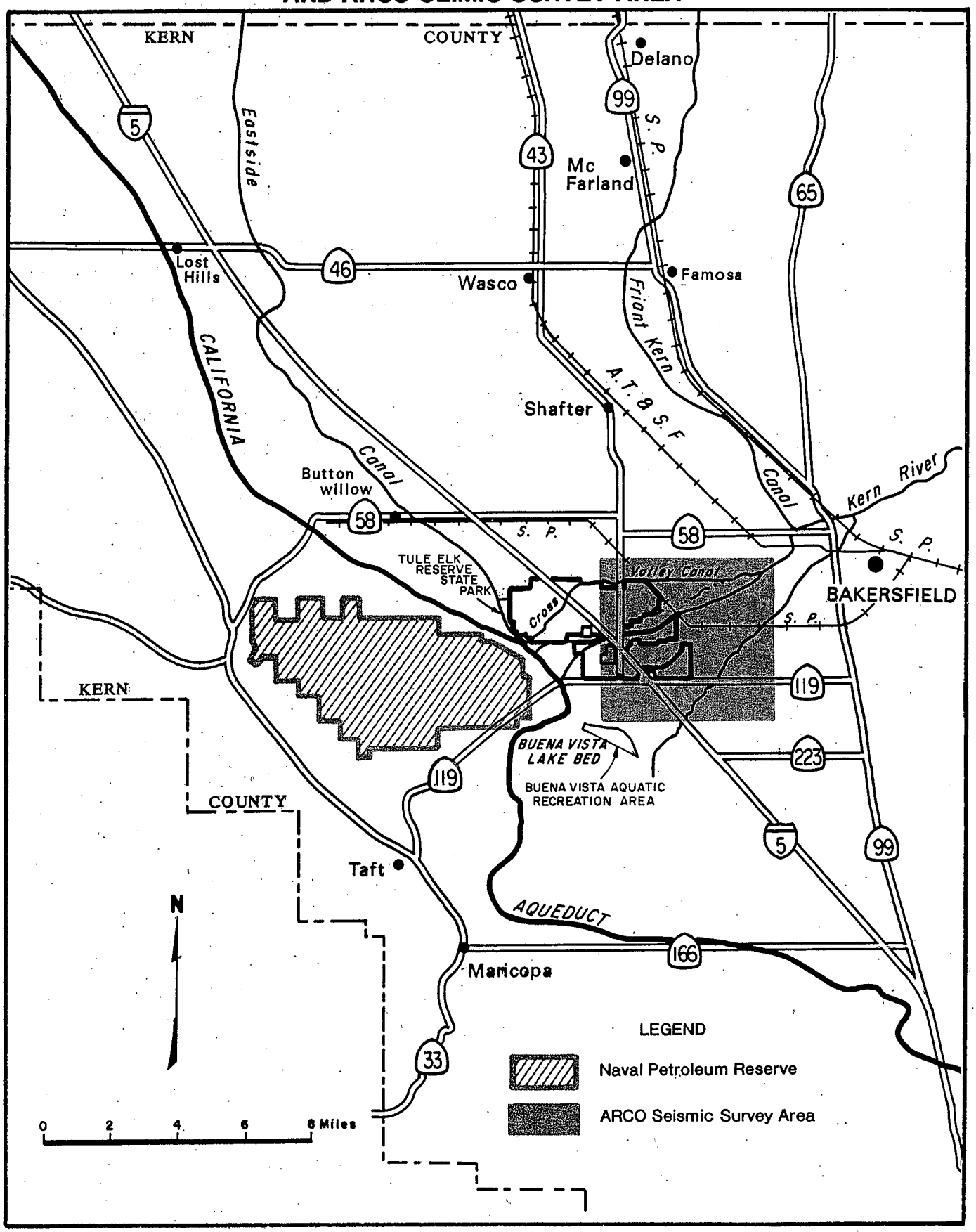
Briefly, the North American Waterfowl Management Plan is a joint Canadian and American (and Mexican) long-term cooperative effort to conserve North American waterfowl and their habitats. The plan provides a framework for waterfowl conservation and management within the foundations set by the 1916 and 1936 Migratory Bird Conventions. Waterfowl populations and habitat inventories have been taken and short- and long-term goals set for the protection and enhancement of waterfowl populations.

As part of the Pacific Flyway, California's Central Valley wetlands provide essential habitat for migratory waterfowl, as well as other native species. Some 60 percent of the migratory waterfowl of the Pacific Flyway winter in California's Central Valley, even though 95 percent of the valley's wetlands have been destroyed. Consequently, the Central Valley Habitat Joint Venture's goal is to protect and improve existing wetland habitat and restore degraded habitat to increase Central Valley waterfowl populations commensurate with goals set by the North American Plan. The objectives include:

- Protecting 80,000 additional acres of existing wetlands.
- Acquiring more than 400,000 acre-feet of firm water supply for use by federal, State, and local refuges and wildlife management areas.
- Securing affordable power for pumping water for public and private wetlands.
- Decreasing Central Valley wetland area by 120,000 acres.
- Enhancing 290,000 acres of public and private wetlands.
- Enhancing wetlands on nearly one-half million acres of agricultural land.

KFE provides an opportunity to re-establish some wetland habitat in the southern Central Valley through cooperation between State and local private and public agencies and organizations.

## Figure 35 GENERAL LOCATION OF PETROLEUM RESERVE No. 1 AND ARCO SEIMIC SURVEY AREA



Informal discussions have taken place between DWR and DFG concerning the creation of wetland habitat on KFE lands. In addition, wetland habitat creation has been discussed at several of the land use advisory committee meetings, and discussions will continue on the type, extent, and timing of wetland creation as part of the planning and implementation of a long-term KFE land use plan.

## U.S. Naval Petroleum Reserve, No. 1

U.S. Naval Petroleum Reserve, No. 1, is a federally owned petroleum field just west of the KFE near the town of Tupman (Figure). Several threatened and endangered species are known to inhabit Petroleum Reserve, No. 1, lands. Consequently, the U.S. Department of Energy is in the process of assessing the impact of its lease oil operations on threatened and endangered species on Petroleum Reserve lands. Draft supplemental environmental documentation is expected to be released in early 1991.

U.S. Naval Petroleum Reserve, No. 1, lands are near the Kern River corridor and the KFE and could provide an excellent link in efforts to connect access corridors along and adjacent to the Kern River for native wildlife, including several threatened and endangered species.

# Chapter 6. ECONOMIC EVALUATION OF SERVICE AND PROJECT AREA ALTERNATIVES

The purpose of this chapter is to establish economic justification for the preferred alternative vis-a-vis SWP service area and project area alternatives to the project's accomplishments. This section is consistent with discussions in the environmental documentation prepared for the North and South Delta Plans. SWP service area alternatives can be determined by identifying the effect of the project on the costs associated with service area demand and supply management and on the level of shortage-related losses. Because the project would provide for a reduction of ground water pumping costs to local users due to elimination of agriculture on the project site, a continuation of the current agricultural pumping cost regime is the project alternative in the project area. Although the recharge and storage operation of the First Stage is also expected to lower local pumping costs, this effect will be reduced during extraction. The results of the ground water model indicate the overall operation of the project will result in a net pumping cost reduction to local ground water users, but, to be conservative, this was not considered in the economic evaluation.

## SWP SERVICE AREA ECONOMIC EVALUATION

The purpose of this section is to show how the proposed First Stage Kern Fan Element (KFE) project "fits" into overall SWP service area water management from an economic perspective. The primary method for this investigation is based on developing two economically preferred service area water management plans. One plan assumed that KFE was available during the period of analysis, and the other assumed that KFE was not available. The management plans were developed by using all local service area water supply enhancement and demand reduction options that have been identified as reasonably feasible. The two plans represent DWR's projection of the local short-term and long-term water management options that would be employed to reduce the impact of future water supply shortages, assuming that the criterion of economic efficiency would be used to select which options to employ.

Comparing the two plans is the best way to identify the effect of the project on the costs associated with service area water management and on the level of shortage-related losses. The result is a measure of the relative economic merit of KFE for meeting increasing water demands in the context of all feasible water management options. This approach is a broader one than is traditionally used since it employs a comprehensive analysis of local water management alternatives in determining the economic benefits of KFE for water supply enhancement.

Benefits were based on an analysis of the impact of the KFE on the use of SWP service area water supply enhancement and demand reduction measures.

## SWP Service Area Water Management Options

The analyses that follow were prepared by region. Because of the detailed information available for the South Coast Region and its relative importance, a sophisticated risk management analysis of this region was used. It is described briefly here and summarized in Appendix D.

The water supply and demand reduction options examined in the South Coast Region are non-structural and structural options that are in addition to the demand reduction assumed in the calculation of water supply need for DWR Bulletin 160-87, *California Water: Looking to the Future* (November 1987).

***South Coast Region.*** South Coast Region alternatives were evaluated by predicting what reasonable water management programs in the region would look like, both with and without the availability of the proposed facilities. The approach taken in this analysis takes a comprehensive view of water supply reliability, incorporating key information on the frequency, size, and impacts of shortages. Local water managers (and users) must respond primarily to actual year–to–year fluctuations in water supply availability, rather than to an average supply.

As shortages increase in magnitude and regularity, shortage management becomes an increasingly important tool for the local water manager. Shortage management contingency options have been incorporated in the economic risk management analysis prepared for the KFE.

The analysis also accounts for the value of avoiding extreme shortage events. Summary statistics, such as firm and average yield, do not show that one event of a specified shortage amount can be much more damaging than two events of half that magnitude, for example. This is particularly true when there are intervening years of no shortfall in the latter situation and when shortage management can mitigate some of the impacts of the smaller shortages.

Looking at year–to–year water supply availability in the context of what local shortage management contingency options can and cannot do to mitigate adverse impacts, and relating those impacts to shortages of specific sizes, is critical in assessing the value of enhanced reliability. This is especially important in light of the increasing environmental and economic costs of enhancement. The economic risk analysis evaluates the economic feasibility of the level of reliability enhancement provided by any combination of facilities, considering the shortage management techniques locally available.

Local water management program options were divided into three categories:

- shortage contingency demand management and supply enhancement options;
- long–term demand management and supply enhancement options; and
- risk management.

**Shortage Management Contingency Options.** Contingency water management options are measures implemented during shortages only (although they may be based on long–term plans and/or agreements) and are intended to minimize the impacts of those shortages. Such measures include (1) using banked local ground water, (2) using local carryover storage, (3) reducing water deliveries to interruptible programs, (4) purchasing water to augment normal sources of supply, (5) instituting extraordinary conservation measures, and (6) rationing.

The extraordinary conservation measures include: alternate–day watering, water patrols, emergency water pricing programs, and intensive public education campaigns. Rationing is assumed to

include setting allowable use quantities and providing for exemptions arising from extraordinary hardship for residential users and adverse economic impact for businesses (forced layoffs, for example) due to the severity of the shortage.

See Table 17 for a list of shortage management contingency options, the limit of their effect on demand, and their expected order of use. These options are assumed to be available in the South Coast Region throughout the study period.

**Table 17. M&I Shortage Contingency Options in the South Coast Region (In expected order of use)**

| Option | Maximum Potential Effect | Use Constraints |
|---|---|---|
| 1. Institute public relations campaign to heighten conservation awareness, use alternate-day watering, gutter-flooder patrols, etc. | 7 percent of demand | Implementation limited if local stored water situation is excellent, compared to shortage. |
| 2. Cut back on deliveries to MWD member agencies for ground water recharge through spreading. | 140,000 acre-feet | Frequency of cutbacks affects participation in interruptible program. |
| 3. Purchase emergency imported ,supply through long-term water marketing agreement. | 50,000 acre-feet | Purchase frequency not to exceed once every five years. |
| 4. Cut back on deliveries to MWD member agencies for reservoir carryover storage. | 35,000 acre-feet | Frequency of cutbacks affects participation in interruptible program. |
| 5. Cut back on deliveries to MWD member agencies for reservoir carryover storage. | 175,000 acre-feet | Frequency of cutbacks affect participation in interruptible program. |
| 6. Use local reservoir carryover storage. | As available | Rule curve limits use. |
| 7. Use local ground water banked within the service area in previous year. | As available | Rule curve limits use. |
| 8. Use local ground water banked through an exchange agreement with another agency. | As available | Rule curve limits use. |
| 9. Cut back on deliveries to MWD member agencies made under the interruptible agricultural delivery program. | 74,000 acre-feet | Cut back only after shortage in previous year and three-year cumulative cut not to exceed 100 percent. |
| 10. Cut back on deliveries to MWD member agencies made under the interruptible agricultural delivery program. | 50,000 acre-feet | Three-year cumulative cut not to exceed 100 percent. |
| 11. Institute a rationing program designed to minimize adverse economic impacts (provide for business exemptions based on economic hardship). | N/A | Not imposed unless 20 percent shortfall remains after foregoing measures. |

**Long–Term Options.** Local long–term water management options to increase reliability that were considered included (1) waste water reclamation, (2) desalinization of brackish drainage and ground water, (3) desalinization of seawater, and (4) the development of water by importation, using long–term conservation facilities in other geographic areas. Also included were ultra low–flush toilet retrofit and leak detection programs in the service area. All these programs are extraordinary measures; that is, they are beyond those assumed to be used in DWR Bulletin 160–87 and are intended to develop and/or conserve water continuously.

Table 18 is a summary list of local long–term options assumed to be available in the South Coast Region. For the year 2000, it was assumed that reclamation projects now in the conceptual stage, rather than in the planning stage, would not be available. The options are ranked in the assumed order of implementation (based on using those with the lowest unit cost first). The water reclamation options are weighted average values for individual projects. The options are described in the following paragraphs and are also described in detail in Appendix D.

Unit cost, water produced or conserved by each option, and cumulative quantities are also shown in Table 18. Costs shown are in 1989 dollars and are computed using noninflated dollars and a 6 percent discount rate. The energy cost component of each alternative is assumed to escalate at 1.7 percent per year during the study period. These criteria, which are used to compare alternatives, are consistent with those used for developing the costs of the proposed SWP action.

**Table 18. Local Long-Term Options – South Coast Region**

| Order of Use | Local Option Type | Product (TAF) | | | Cumulative Product (TAF) | | | Unit Cost ($/AF) |
|---|---|---|---|---|---|---|---|---|
| | | 1995 | 2010 | 2035 | 1995 | 2010 | 2035 | |
| 1[1] | Water reclamation (set 1) | 0 | 23 | 23 | 0 | 23 | 23 | 117 |
| 2[1] | Water reclamation (set 2) | 13 | 13 | 13 | 13 | 36 | 36 | 224 |
| 3 | Residential water audits | 95 | 95 | 95 | 108 | 131 | 131 | 291 |
| 4[1] | Water reclamation (set 3) | 49 | 59 | 59 | 157 | 190 | 190 | 350 |
| 5 | Ultra low flush toilet retrofit | 145 | 290 | 290 | 302 | 480 | 480 | 357 |
| 6 | South Coast ground water desalting | 78 | 78 | 78 | 380 | 558 | 558 | 386 |
| 7 | Imperial drainage water desalting | 302 | 302 | 302 | 682 | 860 | 860 | 417 |
| 8 | San Joaquin Valley drainage water desalting | 139 | 214 | 337 | 821 | 1,074 | 1,197 | 427 |
| 9[1] | Water reclamation (set 4) | 9 | 22 | 22 | 830 | 1,096 | 1,219 | 441 |
| 10 | Riverside County drainage desalting | 42 | 42 | 42 | 872 | 1,138 | 1,261 | 468 |
| 11[1] | Water reclamation (set 5) | 1 | 30 | 30 | 873 | 1,168 | 1,291 | 618 |
| 12[1] | Water reclamation (set 6) | 19 | 32 | 32 | 892 | 1,200 | 1,323 | 781 |
| 13 | Sea water desalting | 5 | 5 | 5 | 897 | 1,205 | 1,328 | 1,783 |

[1]These groupings are based on unit cost; for more details, see Appendix D.

*1. Water Reclamation (Set 1).* See Appendix D. For year 1995, no projects are available in this group. For the period 2010 to 2035, it includes three projects producing a total of 23,000 AF. The weighted average cost of these projects is $117 per AF.

*2. Water Reclamation (Set 2).* See Appendix D. For the period 1995 to 2035, this option includes two projects producing a total of 13,000 AF at a weighted average cost of $224 per AF.

*3. Residential Water Audits.* These would be conducted by water agency representatives, following aggressive promotional campaigns by the water agency. The audits are free to the property owner, but since they are voluntary; the number of households benefiting from the audit was estimated at 50 percent. Under the program: (1) water uses are identified and discussed with householders; (2) low-flow shower heads, toilet tank displacement dams, and faucet aerators are offered for installation by the agency; (3) toilet leaks are repaired; and (4) advice on reducing landscape and other exterior water uses is provided. Water savings are estimated to be 94,700 AF per year.

*4. Water Reclamation (Set 3).* See Appendix D. For year 1995, this option includes six projects that produce 49,000 AF. For the period 2010 to 2035, this option includes seven projects that produce a total of 59,000 AF. The weighted average cost of these projects us $350 per AF.

*5. Ultra–Low–Flush Toilets.* These use 1.6 gallons per flush (gpf), compared to about 5.5 gpf for conventional toilets installed before 1978 and 3.5 gpf (low–flush) toilets installed beginning in 1978. (State legislation requires the installation of 3.5-gpf toilets after 1977.) For Bulletin 160–87, it was assumed that 1.6-gpf toilets would be required in all new construction after January 1, 1995. State legislation is pending. If most 5.5-gpf toilets were replaced with 1.6-gpf toilets, at a minimal savings of 0.018 AF per person per year, the potential savings is 290,000 AF per year. This program would require a 10–year conversion period. Half the ultimate savings of 290,000 AF could be available in 1995.

*6. South Coast Region Ground Water Desalting.* Locations and quantities of desalted water potentially available from this source are:

| County | Annual Yield (AF) |
|---|---|
| Ventura | 10,000 |
| Los Angeles | 12,000 |
| Riverside | 17,000 |
| San Diego | 20,000 |
| San Bernardino | 19,000 |
| **Total** | **78,000** |

*7. Imperial Drainage Water Desalting.* Imperial Irrigation District could use desalted agricultural water in lieu of Colorado River deliveries. As with the Imperial Valley conservation and transfer alternative, Metropolitan Water District would then divert a corresponding amount from the Colorado River Aqueduct. The costs of desalting and transportation through the aqueduct were taken into account. The cost of substituting poorer quality Colorado River water for urban use, was not considered.

*8. San Joaquin Valley Drainage Water Desalting.* A program of desalting brackish agricultural drainage water would allow further local reuse of that water as a substitute for water imported from the Delta so that more water would be available to Southern California. Whereas the quality of imported water (280 mg/L TDS) would differ from that of the desalting product water (500 mg/L TDS), blending small desalting product water flows with the much larger imported water flows would make little difference until the amounts of desalting product water reached very high levels. Due to the complexity of the water transfer facilities, no attempt has been made to calculate those differences, even with the maximum potential flows of desalting product water.

The estimated potential annual yield of desalted drainage water is 139,000 AF per year in 1995, increasing to 337,000 AF per year in 2035. This assumes that only drainage water from the Tulare Lake Basin is totally captured for desalting. Drainage water in the San Joaquin Basin will probably continue to be discharged to the San Joaquin River, as long as water quality objectives in that river are met. To the extent that the available drainage water will be either reused for agriculture, used for ground water management, or discharged to evaporation ponds, it will be unavailable for desalting.

*9. Water Reclamation (Set 4).* See Appendix D. For year 1995, this option includes four projects that produce 9,000 AF. For the period 2010 to 1035, this option includes ten projects that produce 22,000 AF. The weighted average cost of these projects is $441 per AF.

*10. Riverside County Drainage Water Desalting.* Water provided from this source was assumed to be available for agricultural reuse in Coachella Valley. Estimated yield is 42,000 AF per year by

1995 and thereafter. The cost of this option includes conveyance facilities for the desalted water and pumping for reuse and conveying exchange water from the Colorado River to the South Coast Region.

*11. Water Reclamation (Set 5).* See Appendix D. For year 1995, this option includes one project that produces 1,000 AF. For the period 2010 to 2035, this option includes nine projects that produce 30,000 AF. The weighted average cost of these projects is $618 per AF.

The small benefit to irrigated agriculture of using higher quality desalted water (500 mg/L TDS) rather than Colorado River water (700 mg/L TDS) was not subtracted from the cost of this alternative because of complexities such as leaching requirements. Estimated yield is 302,000 AF by 1990 and thereafter.

*12. Water Reclamation (Set 6).* See Appendix D. For year 1995, this option includes three projects that produce a total of 19,000 AF. For 2010 to 2035, the option includes six projects that produce 32,000 AF. The weighted average cost of these projects is $781 per AF.

*13. Sea-Water Desalting.* In seawater desalting, reverse osmosis is now competitive with more traditional forms of desalination, even in the case of a dual–purpose project involving both power production and desalting. In the past, desalting combined with power production almost automatically meant a distillation process using waste heat from the power plant. This is no longer true for the current reverse osmosis plant designs with improved membranes and energy recovery turbines.

**Risk Management.** Another long–term management strategy evaluated was the explicit evaluation of risk with regard to the optimal level of use of the long–term management options. Using this strategy calls for explicitly evaluating the economic cost of shortages based on their expected frequency and magnitude and available contingency shortage management measures. The results of that evaluation are then used in conjunction with an analysis of the cost and effectiveness of available long–term water management measures to determine which of these measures are reasonable from an economic standpoint.

**Identification of South Coast Region Impacts.** To evaluate the alternatives to the KFE, it was assumed that the shortage management contingency options available would be those that could reasonably be expected to be available during the study period, using the criteria of physical and political feasibility. Because the same options would be used, both with and without the KFE — their use dictated by the severity and duration of shortages — they can be considered as alternatives to the KFE only in terms of the frequency and extent of their use. It was also assumed that a risk management strategy, as described above, would be applied, whether or not the KFE was in place. This evaluation assumed South Delta Program facilities would be in place for the year 2010 and year 2035 runs. A revision of the U.S. Army Corps of Engineers' permit to allow pumping from the Delta at 10,300 cfs was also assumed. For the year 1995, it was assumed that the Cross Valley Canal wheeling agreement was in effect. The South Coast Region approach required the use of a simulation model that would approximate, to a reasonable degree, the use of local contingency measures that would actually be seen in response to shortages of various sizes and durations. The economic cost of shortages could then be determined by tying implementation costs to the use of these measures and adding these to an estimate of the economic losses that would be incurred by water users after all reasonable mitigation measures were employed. For this study,

the value of losses to users was derived from the current marginal cost of water to residential users and a recent residential user survey on the willingness to pay to avoid water shortages.

Table 19 shows the relationship between potential water shortages to households as a percentage of normal use and the median willingness to pay to avoid such shortages. These values were used in the simulation model in functional form to estimate losses.

**Table 19. Willingness to Pay ($ per household)**

| Sufficiency Ratio | AF/YR Per Household | | |
|---|---|---|---|
| | .75 | .65 | .50 |
| .95 | $ 25 | $ 22 | $ 17 |
| .90 | 76 | 66 | 51 |
| .85 | 151 | 131 | 101 |
| .80 | 249 | 215 | 166 |
| .75 | 366 | 317 | 366 |
| .70 | 502 | 435 | 355 |
| .65 | 654 | 567 | 436 |

Figure 36 is a flow chart of the Economic Risk Model. Appendix D contains a detailed description of the logic of the model, the parameters used, and the general assumptions.

In brief, the model was run on the 57-year (1922 to 1978) hydrologic record for year-1995 level, year-2010 level, and year-2035 level demands. The operational considerations cited previously were applicable. Two sets of runs were made at each demand level; the only difference was the existence of the KFE. One set assumed their existence; the other set did not. Within each set, runs differed only by the amount of additional water made available by the use of local extraordinary long-term water supply enhancement and demand management options. Runs were made by using increments of 20,000 AF of additional local water up to a maximum of 1 million AF.

Average municipal and industrial (M&I) consumptive use for the South Coast Region was based on numbers produced for DWR Bulletin 160-87. These numbers were updated in accordance with regional population allocations developed by DWR from statewide interim projections produced by the Department of Finance for years 2000 and 2010. These projections were also used by DWR to update the 2035 projection appearing in the South Delta Water Management Plan Draft EIR/EIS, June 1990, for the South Coast Region.

Variation in the year-to-year level of M&I consumptive use was simulated within the Economic Risk Model, based on historic climatic conditions in the South Coast Region during the 57-year period of hydrologic record. The variance in consumptive use driving the simulation was based on an estimate made in a study conducted for The Metropolitan Water District of Southern California by Chesnutt and McSpadden, *Statistical Analysis of Water Demands During the Current Drought* (January 1989). Each run (at a specified increment of local supply) was made 30 times for each of the 57 years of hydrologic record. This allowed for the resimulation of consumptive use each time to derive a sufficiently reliable estimate of the expected value of the economic costs and losses.

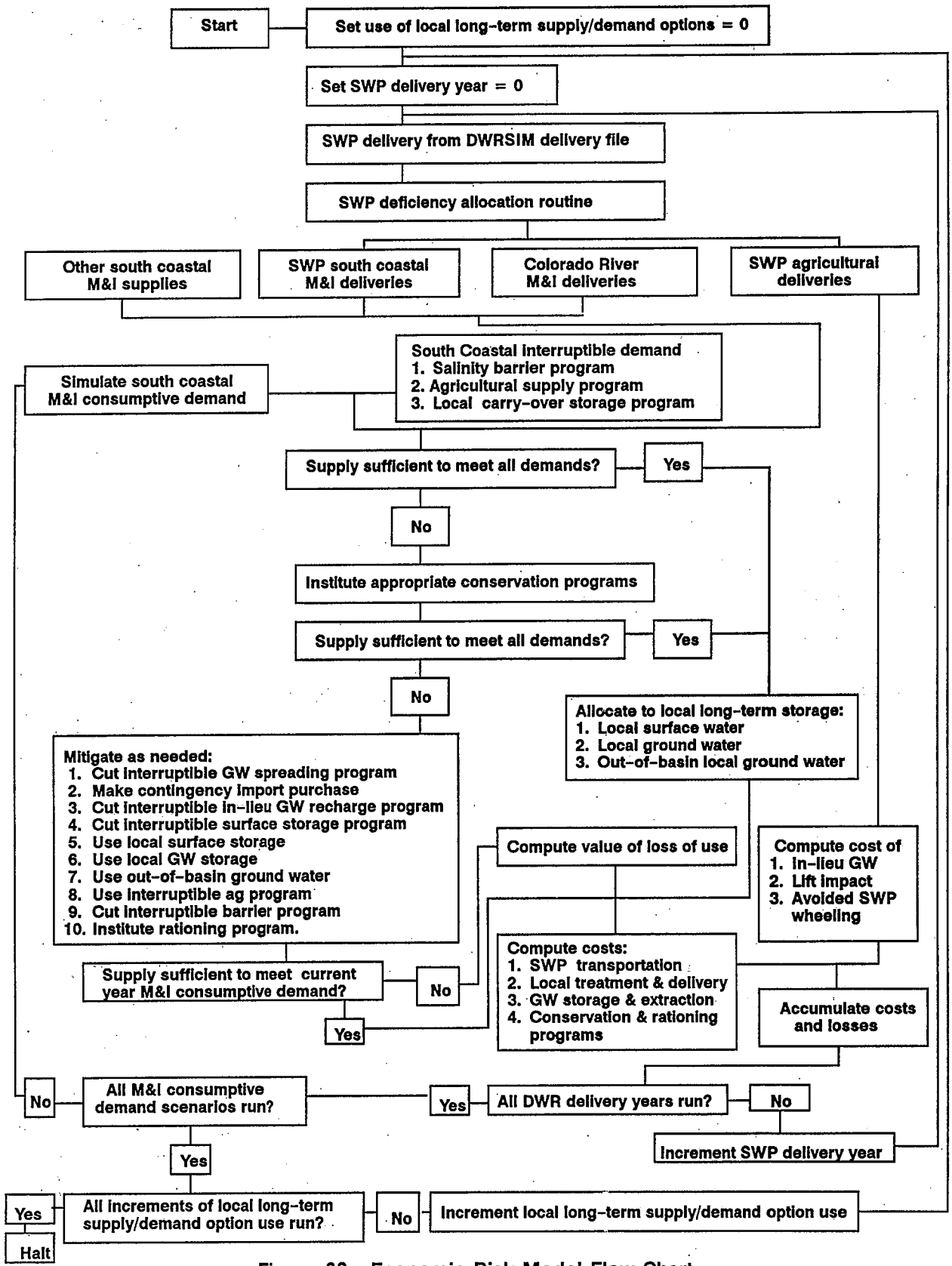



Figure 36. Economic Risk Model Flow Chart

For each of these runs, expected economic costs and losses were computed and compared to the cost of the local extraordinary long-term water management options used. On this basis, an optimal use of these options could be established using the risk management criterion. Because risk management is not costless, this level of optimal use of local management options still allows for an associated level of expected losses. Any further reduction in expected losses would not be cost-effective, compared to the higher cost of the remaining options.

Table 20 shows how the economic risk model run results were used to identify those local options that would no longer be needed under the risk management criterion, if the KFE were in place. For each of the study years, the option, part of the option, or combination of options no longer needed — along with the acceptance of additional risk — is properly designated as the alternative to the KFE. For each study year, the first column shows the use in thousands of acre-feet of local options without the KFE available. The second column shows the effect of the KFE on total local option use. The third column shows the change in local option use attributable to the KFE — the KFE local option use alternative.

Expected economic costs and losses were compared to the cost of the local extraordinary long-term water management options used. On this basis, an optimal use of these options could be established, using the risk management criterion.

***Tulare Lake Region.*** Management options for this region were examined for two classes of users: agricultural and municipal and industrial.

**Agricultural Users.** For individual farmers using SWP agricultural deliveries in this region, local options for water supply and demand management include:

- Pumping ground water (if farm overlies a ground water basin).
- Increasing on-farm water application efficiency.
- Exchanging supplies within the local water agency from areas with alternative supplies to those without.
- Stressing crops by failing to meet full evapotranspiration requirements.
- Reduce planted acreage of annual crops.

Based on the 1976-77 drought experience, which included the drilling of many additional wells, it was assumed that any additional increment to SWP delivery curtailments due to the absence of the KFE will be compensated for by local ground water pumping. For areas that do not overlie ground water, the 1976-77 experience demonstrated local water agency flexibility in setting up contingency exchanges with those areas with available supplies. Reinforcing this expectation is the fact that potential net water savings from increased on-farm efficiency in the Tulare Lake region are small to nonexistent because of already high on-farm and basin efficiencies. In addition, crop stressing is a high-risk strategy and leaving non-program farmland idle is costly.

**Table 20**
**Local Service Area Alternatives, Local Long-Term Option Use—South Coast Region (TAF)**

| Local Option ID | Available Product 1995 | Available Product 2010 | Available Product 2035 | Year 1995 Without Project | Year 1995 With Project | Year 1995 Option Use Alt. | Year 2010 Without Project | Year 2010 With Project | Year 2010 Option Use Alt. | Year 2035 With Project | Year 2035 Without Project | Year 2035 Option Use Alt. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WR1 | 0 | 23 | 23 | 0 | 0 | 0 | 23 | 23 | 0 | 23 | 23 | 0 |
| WR2 | 13 | 13 | 13 | 13 | 13 | 0 | 13 | 13 | 0 | 13 | 13 | 0 |
| RWA | 95 | 95 | 95 | 56 | 33 | 23 | 95 | 95 | 0 | 95 | 95 | 0 |
| WR3 | 49 | 59 | 59 | 0 | 0 | 0 | 59 | 59 | 0 | 59 | 59 | 0 |
| ULFTR | 145 | 290 | 290 | 0 | 0 | 0 | 131 | 100 | 31 | 290 | 290 | 0 |
| SCR GWD | 78 | 78 | 78 | 0 | 0 | 0 | 0 | 0 | 0 | 78 | 78 | 0 |
| IID DWD | 302 | 302 | 302 | 0 | 0 | 0 | 0 | 0 | 0 | 126 | 105 | 21 |
| SJV DWD | 139 | 214 | 337 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WR4 | 9 | 22 | 22 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| RC DWD | 42 | 42 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WR5 | 1 | 30 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| WR6 | 19 | 32 | 32 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SWD | 5 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Quantity Used/Displaced** | | | | **69** | **46** | **23** | **321** | **290** | **31** | **684** | **663** | **21** |

The cost of using ground water as an alternative in the Tulare Lake Region includes the cost of energy for the additional pumping in the year of curtailment related to the absence of the KFE and the cost of managing any exchange programs necessary to get additional water to areas without ground water pumping capability. Also, because the Tulare Lake Region is in a condition of long-term ground water overdraft, the additional pumping in any single year will cause an increase in pumping depth, which will result in a long-term increase in all pumping costs.

A conservative estimate of these pumping costs impacts made for this report is $75 per AF. This estimate was based on a March 1985 DWR San Joaquin District Memorandum Report, "A Method for Estimating the Value of Surface Water in Conjunctive Use Areas."

**Municipal and Industrial Users.** SWP M&I users in the Tulare Lake Region were assumed to have the same capability for ground water pumping and/or contingency exchange as the agricultural users in the region. The cost of these alternatives to the M&I users was assumed to be at least as high at the current cost of the M&I supply, minus the cost of local treatment and delivery. This value was estimated to be $230/AF, based on a DWR water price survey.

***Sacramento River Region.*** The M&I water users in this region are assumed to have access to local surface water as a supply management option. Using the weighted average SWP equivalent unit water cost of $21 per AF as a conservative alternative cost, DWR assumes that the cost of using the alternative supplies is at least as great as the cost of the current SWP supply. DWR Bulletin 132-89, *Management of the California State Water Project* (DWR, November 1989), was the source of the equivalent unit cost.

***South Lahontan Region.*** SWP deliveries are made to this region for both agricultural and urban uses. Because of the rapid urbanization taking place and the absence of supply options, urban users depend on both the phasing out of local agriculture and an increase in SWP deliveries to meet their future needs. Even with the use of additional local water exchanges and extraordinary

shortage–management programs, the growth in urban demands will result in even more frequent and severe economic losses due to shortages. Without the KFE, this situation would worsen.

***Colorado River Region.*** Water management options in this region include additional waste water reclamation and water sharing with agricultural users on a contingency basis. The frequency and extent of sharing would have to be restricted to avoid unacceptable economic impacts within the agricultural sector. The acceptance of additional economic risk would also be a likely consequence of the absence of the KFE.

***San Francisco Bay Region.*** Water management options in this region include additional waste-water reclamation, water exchange agreements among local water agencies, and the acceptance of additional economic risk. It is reasonable to assume that the value of the alternatives will exceed the current value of urban water of about $440 per AF. This value was obtained from a DWR water price survey.

***Central Coast Region.*** The situation in this region is characterized by costly water supply options in the face of increasing use due to population pressure. After assuming extraordinary conservation measures, consisting of an ultra–low-flush toilet retrofit program and residential water audits, a combination of local water supply options will be required to meet urban demands. These options include reservoir construction ($800 per AF), pipeline construction ($435 per AF), and sea-water desalination ($2,140 per AF). This conclusion was the result of research conducted for the Coastal Aqueduct Draft EIR prepared by DWR. In light of those costs, it seems reasonable to assume that shortage contingency demand and supply management strategies similar to those used for the South Coast Region analysis would be applicable to this region. Accordingly, the cost of local alternatives in this region was assumed to be proportional to those determined for the South Coast Region.

## SWP Economic Benefits

Economic benefits of the proposed KFE were determined by using the Economic Risk Model directly for the South Coast Region and SWP agricultural contractors in Kings and Kern counties and indirectly for the Central Coast Region. Current water costs were used to estimate willingness to pay for water in the San Francisco Bay, Tulare Lake, and Sacramento River region.

***South Coast Region Benefits.*** The benefits of the KFE for the South Coast Region depend on the extraordinary local water supply and demand management options that would be employed with and without the proposed KFE. Either the costs of the options that could be displaced by the existence of the proposed KFE, the expected economic losses that would be avoided with the proposed KFE, or both (if appropriate) could then be properly attributed to the KFE facilities as benefits.

Table 21 and Figure 37 were developed by using the procedure described for determining the optimal employment of local options and noting the expected loss values associated with each level of use of the options.

It is important to note that the lower the use of the local options, the higher the value of the KFE for reducing risk. The avoided economic loss benefit of the KFE would be more than proportionally greater to the degree that the extraordinary local options are not available or are more costly

**Figure 37. Kern Fan Element**
**South Coastal Service Area Options Displaced by KFE Yield**

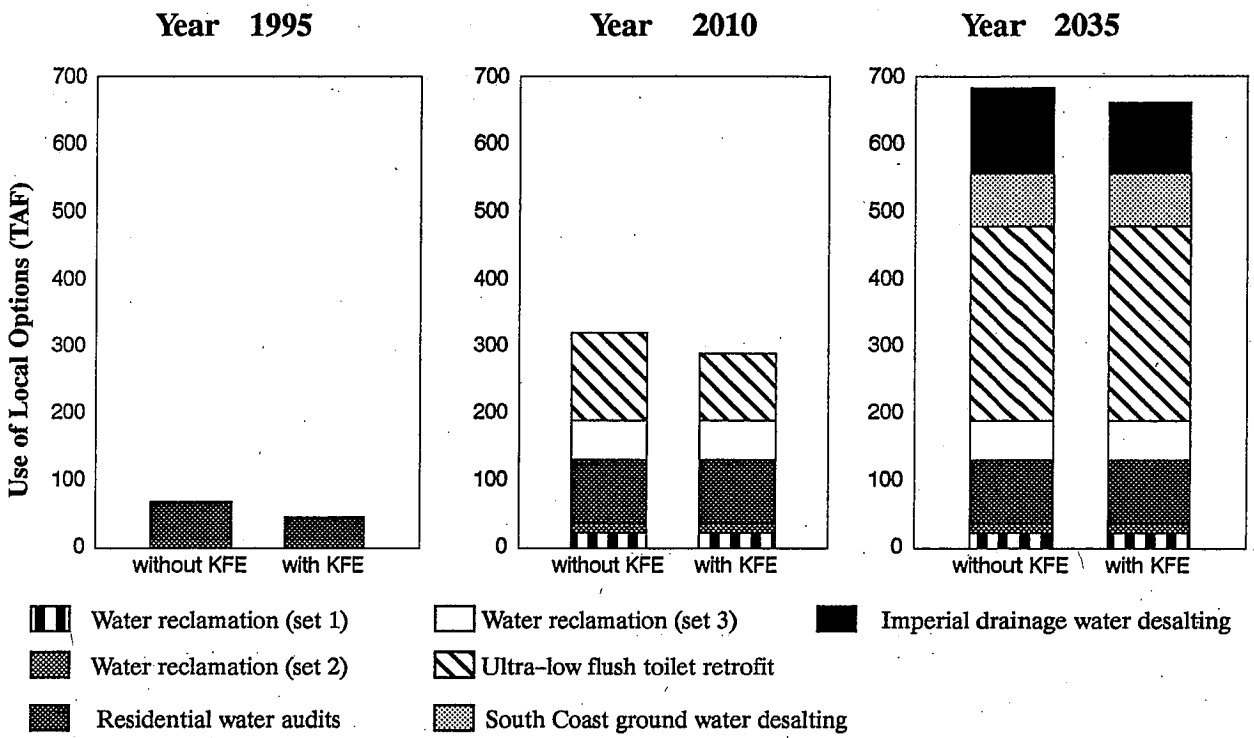



**Table 21. Analysis of the First Stage Kern Fan Element, South Coast Region**

| Variable | Demand Level | | |
|---|---|---|---|
| | 1995 | 2010 | 2035 |
| **Water Use (TAF)** | | | |
| Use of local options: | | | |
| Without KFE | 69 | 321 | 684 |
| With KFE | 46 | 290 | 663 |
| Avoided use of local options | 23 | 31 | 21 |
| **Benefits (millions of dollars)** | | | |
| Change in avoided losses due to reduction in use of local options | -7.5 | -12.3 | -15.1 |
| Avoided local option costs | 6.9 | 11.2 | 14.1 |
| Net gain from reduction in use of local options | -.6 | -1.1 | -1.0 |
| Benefit of KFE at reduced local option use | 11.7 | 9.9 | 22.9 |
| Adjusted KFE benefit | 11.1 | 8.8 | 21.9 |

than assumed. This is an important observation because of the uncertainty about the environmental, legal, and health aspects problems associated with some of the options.

The analysis, based on the marginal value of expected losses avoided equated to marginal costs of local water supply/demand management options, is a conservative way of interpreting the model results with respect to estimating the benefits of the KFE. If local water managers (and users)are more risk-averse than indicated by this type of analysis — which is a reasonable assumption — the benefits will be higher than indicated. Under the assumption of greater risk-aversion, the avoided cost of the local options that would be displaced by existence of the facilities becomes more important. Because it is the increasingly costly options that would be displaced, the cost savings (that is, benefits) arising from use of the facilities to attain the desired level of risk become very large.

The conservative assumption of a linear build-up in demand between year-1995 and year-2035 demand levels was made to facilitate the computation of the equivalent annual benefits over the study period. This value for the South Coast Region was determined to be $10.6 million. The benefit build-up from zero in 1990 to the 1995 value was also assumed to be linear.

The basis for this computation was a 6 percent discount rate and a 50-year period of analysis. Benefits for the years after 2035 were assumed to remain at the 2035 level.

***Agricultural Benefits for SWP Service Areas in the Tulare Lake Region.*** The Risk Model results were used directly for this benefit computation because of the conservative simplifying assumption that benefits are constrained to the alternative cost of pumping in lieu of SWP agricultural deliveries. This was felt to be conservative because facilities to bring ground water through intra-agency exchanges are not available for all areas that do not overlie ground water. In addition, the consequences of relying on in-lieu pumping in areas with critical overdraft problems were not addressed by this analysis. The model runs produced the following results for agricultural losses, adjusted for the avoided SWP transportation costs (Table 22). Based on this approach, the expected equivalent annual benefits were calculated to be $1.2 million.

***Benefits in Other SWP M&I Service Areas.*** The Economic Risk Model has not been applied directly to other SWP municipal and industrial areas because the necessary information on either the reliability or cost of local supplies, the availability and effectiveness of local water supply, and demand management options was unavailable. The following regions were those in which the major portion of the KFE benefits were expected to occur.

**Central Coast Region.** The situation in this area is characterized by costly water supply options in the face of rising use from population pressure. On the basis of this knowledge, it was felt to be conservative, with respect to the value of the proposed KFE, to apply the benefits and results determined for the South Coast Region to this area. This was done by assuming benefits in proportion to relative entitlement. This amount was determined to be about $300,000 annually.

**San Francisco Bay Region.** Average urban water rates in the North Bay SWP service area are presently about $445 per AF. For the South Bay this figure is about $415 per AF. Adjusting these values for local treatment and delivery cost, plus SWP conveyance, would translate them to about $390 and $360 per AF, respectively, at the Delta. Assuming these values to be year 2000-level values is conservative. For 2035, it was assumed that they would rise linearly from year 2000 to $500

per AF, less than is currently being paid in Southern California high–cost areas. Using an average increment of yield from the proposed project to this area of 1,400 AF in 1995, rising to 3,400 AF in 2035, the benefit value was computed to the equivalent of about $1.1 million.

**San Francisco Bay Region.** Average urban water rates in the North Bay SWP service area are presently about $445 per AF. For the South Bay this figure is about $415 per AF. Adjusting these values for local treatment and delivery cost, plus SWP conveyance, would translate them to about $390 and $360 per AF, respectively, at the Delta. Assuming these values to be year 2000–level values is conservative. For 2035, it was assumed that they would rise linearly from year 2000 to $500 per AF, less than is currently being paid in Southern California high–cost areas. Using an average increment of yield from the proposed project to this area of 1,400 AF in 1995, rising to 3,400 AF in 2035, the benefit value was computed to the equivalent of about $1.1 million.

**Table 22. Annual Agricultural Benefits ($ millions)**

| | Years | | |
|---|---|---|---|
| | 1995 | 2010 | 2035 |
| Expected agricultural losses: | | | |
| Without NDP | 16.7 | 30.0 | 45.7 |
| With NDP | 15.7 | 28.5 | 43.5 |
| Avoided losses | 1.0 | 1.5 | 2.2 |

**Tulare Lake Region.** The average urban water rate presently being paid for urban water in this area is $268 per AF. Adjusting this for SWP conveyance cost and local treatment and distribution results in a net value of $230 per AF. This value was assumed to remain constant throughout the study period. An average increment of yield from the proposed facilities to this area of 1,400 AF in 1995, rising to 1,800 AF in 2035, was used to estimate benefits. Based on this, an equivalent annual value of $300,000 was obtained.

***Summary of Annual Benefits.*** The following table shows the benefits derived with the procedures described above. Total benefits of the KFE were estimated to be about $13.6 million annually.

**Table 23. Summary of Annual Benefits**

| Region | Annual Benefit ($ millions) |
|---|---|
| **M&I** | |
| South Coast | 10.5 |
| Central Coast | 0.3 |
| San Francisco Bay | 1.1 |
| Tulare Lake | 0.3 |
| **Subtotal** | **12.2** |
| **Agricultural** | |
| Tulare Lake | 1.2 |
| **Total** | **13.4** |

The foregoing benefit values should be used advisedly for the determination of economic justification for the proposed project for the following reasons:

- The model selects local project alternatives on the basis of a risk-neutral view of risk management. Risk-averse management (risk minimization) by local agencies—which has been the predominant mode—would result in the proposed project displacing more costly water management options than under the risk-neutral assumption.
- The costs developed for the local water management options must be considered very preliminary in comparison to the costs developed for the proposed project. In the preponderance of cases, when a detailed study is made of an option and commensurate refinements are made to cost estimates, the costs increase substantially.
- While the costs developed for the proposed project include mitigation, the costs for the local options do not. Mitigation costs, in those cases where it is required, can be a substantial portion of the final cost. Costs of local options which depend upon the construction of treatment plants and conveyance facilities are most likely to be underestimated for this reason.
- Local options which require the disposal of materials covered by hazardous waste regulations, such as desalting plants and some waste water reclamation plants, may have higher than anticipated costs.
- Some of the local options assumed to be available may not be politically, financially, and/or technically feasible as soon as the model expects or may not be feasible at all. For example, the reclaimed waste water options were based on very liberal assumptions regarding the acceptable uses for this source of supply in light of current regional Water Quality Control Boards and Department of Health Services regulations.
- The model assumes the maintenance of the existing D-1485 Bay-Delta water quality criteria. A new decision coming out of the current SWRCB hearing process is very likely to result in additional restrictions on Delta pumping during times important to fish survival. Projects which provide storage south of the Delta—such as the Los Banos Grandes Facilities—will provide relatively greater water supply accomplishments to the extent that such restrictions are tightened.
- The model assumes that both the South Coast and the Tulare Lake Regions have the facilities and institutional agreements in place to move water as needed to minimize the impact of shortages. Because this is unlikely to be the situation, especially in the case of agricultural use, the model tends to undervalue the benefits of the proposed project for this reason.

In light of the foregoing, the economic benefits must be considered as being a lower bound to the actual benefits of the proposed project.

## LOCAL PROJECT AREA ECONOMIC BENEFITS

When DWR purchased the 20,000-acre KFE property, about 16,000 acres were in agricultural production. By the end of 1993, all agricultural activities on the Kern Fan Element property are planned to be phased out for the project. For the most part, these agricultural lands have relied on ground water for irrigation, except in very wet years on the Kern River when some surface water was available. The reduction and eventual phase-out of all agriculture on the property will result in a net long-term reduction in ground water use by as much as 31,000 AF annually. The project will therefore result in higher ground water levels than would exist without the project, as-

suming that no new lands are placed into production. This will benefit remaining ground water users near the property. The economic present worth of the avoided future pumping costs is about $35.0 million.

# Chapter 7. SIGNIFICANT IRREVERSIBLE ENVIRONMENTAL CHANGES

The proposed project may result in the loss of agricultural uses of the land. Permanent changes in land use also would occur where wells, canals, pumps, and other facilities are needed. Resources and energy required to manufacture the steel and concrete for construction and long-term operation of the proposed project would be irretrievably committed.

# Chapter 8. RELATIONSHIP BETWEEN LOCAL SHORT-TERM USES OF THE ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed project would be capable of transporting water for recharge, storage, and extraction for many years, if the facilities were properly maintained. The short-term uses of the environment would occur primarily during and shortly after construction. The short-term effects would be minimal in relation to the long-term productivity resulting from construction and operation of the proposed facilities.

The project would help correct long-term overdraft conditions in Kern County, increase the delivery capability of the SWP, increase the reliability of imported water supplies, and increase the efficiency of the conjunctive operation of existing SWP facilities with ground water storage. The proposed plan would also provide long-term protection and enhancement of habitat for wildlife.

# BIBLIOGRAPHY


Bartow, J.A., and G.M. Pittman. *The Kern River Formation, Southeastern San Joaquin Valley, California.* U.S. Geological Survey Bulletin 1529-D. 1983.

California Department of Fish and Game. Dan Chapin. Letter to Mary Scoonover; California Department of Water Resources, and copy of the *Working Agreement for Central Valley Habitat Joint Venture of the North American Waterfowl Management Plan,* June 15, 1989.

_____. *Kern Fan Element of the Kern Water Bank.* Fish and Wildlife Resources Draft Report. November 1990.

California Department of Water Resources. *The Hydrologic-Economic Model of the San Joaquin Valley.* Bulletin 214. 1982.

_____. *Ground Water Study, San Joaquin Valley, Third Progress Report.* San Joaquin District Report. 1985.

_____. *Final Environmental Impact Report, Artificial Recharge, Storage and Overdraft Correction Program, Kern County, California (Kern Water Bank).* December 1986.

_____. *Kern River Fan Element, Kern Water Bank, Preliminary Technical Report.* Division of Planning. April 1987.

_____. *California Water: Looking to the Future.* Bulletin 160-87. November 1987.

_____. *Ground Water Study, San Joaquin Valley, Fourth Progress Report.* San Joaquin District Report. 1989.

_____. *Management of the State Water Project.* Bulletin 132-89. November 1989.

_____. *Management of the State Water Project.* Bulletin 132-90. November 1990.

Camp, Dresser, and McKee, Inc. *Kern Water Bank Toxics Assessment Study.* August 1987.

Dale, R.H., J.J. French, and G. Gordon. *Ground Water Geology and Hydrology of the Kern River Alluvial Fan, California.* U.S. Geological Survey Open-File Report. 1986.

Graham, S.A., A.R. Carrol, and G.E. Miller. *Kern River Formation as a Recorder of Uplift and Glaciation of the Southern Sierra Nevada.* Studies of the Geology of the San Joaquin Basin. SEPM Volume 60., pp. 319-332. 1988.

Grunsky, Carl Ewald. *Irrigation Near Bakersfield, California.* U.S. Geological Survey Water Supply Paper 17. 1898.

Marchand, D.E., and A. Allwardt. *Late Cenozoic Stratigraphic Units, Northeastern San Joaquin Valley, California.* U.S. Geological Survey Bulletin 1470. 1981.

Mendenhall, W.C., R.B. Hall, and H. Stabler. *Ground Water in San Joaquin Valley, California.* U.S. Geological Survey Water-Supply Paper 398. 1916.

Pacific Geotechnical Associates, Inc. *Study of the Regional Geologic Structure Related to Groundwater Aquifers in the Southern San Joaquin Valley Groundwater Basin, Southern Kern County, California (Phase 1a).* November 1990

Page, R.W. *Base of Fresh Ground Water — Approximately 3,000 Micromhos, San Joaquin Valley, California.* U.S. Geological Survey Open-File Report. 1976.

Quad Consultants. Bakersfield Arch 3-D Seismic Survey Routes: Natural Environment. Prepared for ARCO Oil and Gas Company, November 1990.

Resources Management Associates. *Hydrologic Modeling Task Report for the San Joaquin Valley Ground Water Study.* 1982.

Stetson Engineers, Inc. *Final Environmental Impact Report, Use and Disposition of Property and Water Rights Acquired by the City of Bakersfield from Tenneco West, Inc., in Settlement of Litigation.* 1975.

Thomas Reid Associates (with Quad Consultants and Tierra Madre Consultants), *Metropolitan Bakersfield Habitat Conservation Plan and Draft Environmental Impact Report for the Metropolitan Bakersfield Habitat Conservation Steering Committee,* September 1990.

United States Department of the Interior, Bureau of Reclamation. *Design of Small Canal Structures.* 1974.

Woodring, W.P., P.V. Roundy, and H.R. Farnsworth. *Geology and Oil Resources of the Elk Hills, California, Including Naval Petroleum Reserve No. 1.* U.S. Geological Survey Bulletin 835. 1932.

# CONSULTATION AND COORDINATION

Kern County Water Agency

Department of Parks and Recreation

Department of Fish and Game

Bakersfield Habitat Conservation Program Committee

Nature Conservancy

U.S. Fish and Wildlife Service

# GLOSSARY

**Acre-foot.** The quantity of water required to cover one acre to a depth of one foot; equal to 43,560 cubic feet or 325,851 gallons.

**Air Stripping.** The process of removing volatile organic contaminants from water by forcing air through it.

**Anticline.** A geologic structure in which beds have been arched upwards.

**Aquifer**. Geologic materials capable of yielding significant amounts of ground water to wells.

**Artificial Recharge.** The addition of water to a ground water reservoir by human activity, such as irrigation or induced infiltration from streams, wells, or recharge basins. See also **Ground Water Recharge; Recharge Basin.**

**Average Annual Dry Period Supply.** The average annual delivery of water to State Water Project contractors for the period March 1928 through February 1935.

**Base Study.** Operation study without the proposed project.

**Basin Area.** Measured basin surface area at full capacity.

**Benefits.** Net increase in the value of goods and services which result from the project, as compared to conditions without the project.

**Carriage Water.** Delta outflow required to protect the quality of water at the CVP and SWP pumping plants.

**Channel Bar.** A sand bar formed in a braided river system.

**Conjunctive Operation.** The operation of a ground water basin in coordination with a surface water storage and conveyance system. The purpose is to recharge the basin during years of above-average water supply to provide storage that can be withdrawn during drier years when surface water supplies are below normal.

**Conservation Facility.** A reservoir, either surface or ground water, that is used to capture or store water during wet periods for later use.

**Coordinated Operating Agreement.** An agreement between the United States Bureau of Reclamation and the Department of Water Resources to coordinate the operation of their projects including storage, releases, and pumping.

**Corcoran Clay.** Widespread geologic unit in the San Joaquin Valley that greatly restricts the vertical movement of ground water. It serves as a confining layer separating deep and shallow ground water systems.

**Critical Dry Period.** A series of water-deficient years, usually a historical period, in which a full reservoir storage system at the beginning is drawn down to minimum storage at the end without any spill.

**Critical Dry Year.** A dry year in which the full commitments for a dependable water supply cannot be met and deficiencies are imposed on water deliveries.

**Decision 1485.** A set of regulations formulated by the California State Water Resources Control Board to protect the beneficial uses in the Delta. They include, among other factors, determination of maximum salinity concentrations at different locations in the Delta.

**Delivered Recharge.** Measured net recharge deliveries into each pond.

**Deltaic.** Sediment deposited in a river delta.

**Delta Water Charge.** A charge to water service contractors under the water service contract used in the State Water Project. The Delta water charge to a particular contractor is intended to recover the portion of the cost of the water conservation facilities allocated to that contractor.

**Dependable Supply (Water).** The annual quantity of water that can be delivered under normal water supply conditions, and with allowable deficiencies during critical dry periods. See also CRITICAL DRY YEAR, FIRM YIELD, PROJECT YIELD.

**Depositional Environment.** The environment in which sediment is deposited (that is, an alluvial fan).

**Detailed Analysis Unit (DAU).** The smallest study area used in the analysis of water use and supply, generally defined by hydrologic features or boundaries of organized water service agencies in the major agricultural areas, a DAU typically includes 100,000 to 300,000 acres.

**Electric Log.** A record of the resistivity and electric potentials in materials exposed in a borehole.

**Endangered Species.** Any species which is in danger of extinction throughout all or a significant portion of its range, other than a species of *Class Insecta* determined by the Secretary to constitute a pest whose protection under the provisions of the Endangered Species Act would present an overwhelming and overriding risk to man.

**Entitlement Water.** Water from the State Water Project that has been contracted for under long-term agreements. The SWP contracts establish specific annual entitlement amounts that each long-term water contractor may request. These schedules reflect each contractor's estimate of future water needs at the time the contracts were signed (with some subsequent revisions).

**Entitlement.** The contracted amount of water for delivery from the State Water Project, as set forth in Table A of each contractor's water supply contract with the Department of Water Resources.

**Evaporable Soil Moisture.** Estimated volume of available soil moisture that could be evaporated or used consumptively by vegetation. Estimated on the basis of recharge basin surface acreage and vegetative acreage.

**Evaporation Rate.** Measured pasture pan evaporation (U.S. Weather Bureau Class A evaporation pan located in an irrigated pasture environment)..

**Extensometer.** A well designed to measure the amount of compaction that occurs in subsurface materials in response to falling water levels.

**Firm Yield.** The dependable annual water supply that can be made available for delivery with exceeding specific reductions (deficiencies) in agricultural deliveries during extended dry periods. Normally determined for the period 1928–1934.

**First Stage, Kern Fan Element.** The first stage of development of the Kern Fan Element program.First Stage, Kern Fan Element.

**Fluvial.** Sediment deposited in a river system.

**Glacio-fluvial.** An environment in which material derived from glaciers is deposited in a river system.

**Gross Recharge.** Computed difference between basin inflow and basin outflow.

**Ground Water Overdraft.** The condition in which the long-term withdrawals from a ground water basin exceed the long-term recharge.

**Ground Water Recharge.**

**Hydrogeology.** The study of the effect of geologic materials on the occurrence, movement, and quality of ground water.

**In-lieu Recharge.** The delivery of supplemental surface water for use in place of use of ground water, resulting in a comparable reduction in ground water use.

**Kern Fan Element.** Direct recharge and extraction program conducted on property overlying the Kern River alluvial fan, west of Bakersfield, purchased by the Department in August 1988.

**Kern Water Bank.** All opportunities by the Department of Water Resources to store and extract imported surface water in the Kern County Ground Water Basin under a contract with the Kern County Water Agency.

**Lacustrine.** Sediment deposited in a lake.

**Liquefaction.** The process in which a soil may lose strength and behave as a liquid in response to earthquake shaking.

**Local Elements.** Proposed direct and indirect ground water recharge and extraction programs with local water districts in Kern County, which are conducted within the boundaries of such districts using existing and proposed additional facilities.

**Maximum Contaminant Level (MCL).** The maximum amount of a chemical that may be in a public water supply. A drinking water standard.

**Mounding.** The rise in the water table below a recharge pond.

**Multiple Completion Monitoring Well.** A monitoring well in which two or more piezometers are installed to measure water levels in discrete zones.

**Natural Gamma Log.** A record of the amount of gamma radiation produced by materials in a borehole. A measure of the relative amount of clay present.

**Nematicides.** A pesticide designed to kill nematodes.

**Perched Water.** A condition in which shallow clay layers cause ground water levels to be near the surface.

**Phreatophyte.** A deep-rooted plant that obtains its water from the water table or the layer of soil just above it.

**Phreatophyte Area.** Estimated vegetation area surrounding each pond.

**Point Bar.** A sand bar formed at the bend of a river. Tends to form sheets of sand in the subsurface.

**Pond Area.** Measured pond surface area at full capacity.

**Recharge Basin.**

**Resistivity Log.** A record of the resistance to an electrical current in the materials exposed in a borehole. Used to estimate relative permeabilities.

**Shaliness.** The relative amount of silt and clay in materials exposed in a well bore.

**Spontaneous Potential Log.** A record of the natural electrical currents generated between geologic materials and fluids in a borehole.

**Storativity.** The volume of water released from or taken into storage from a unit volume of aquifer per unit change in head.

**Subsidence.** The sinking of the land surface, caused by compaction of subsurface material in response to declining water levels.

**Sumps.** Pits constructed to dispose of brine produced with oil.

**Unconformity.** A geologic surface at which the orientation of beds above and below is different. Represents a time when no material was being deposited.

**Vadose.** The unsaturated part of an aquifer.

# ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| **AADPS** | average annual dry period supply |
| **AF** | acre-feet |
| **ASTM** | American Society of Testing Materials |
| **BVWSD** | Buena Vista Water Storage District |
| **CEQA** | California Environmental Quality Act |
| **cfs** | cubic feet per second |
| **CVC** | Cross Valley Canal |
| **CVP** | federal Central Valley Project |
| **DAU** | Detailed Analysis Unit |
| **DBCP** | 1,2–dibromo–3–chloropropane, an agricultural pesticide |
| **DFG** | California Department of Fish and Game |
| **DHS** | California Department of Health Services |
| **DWR** | California Department of Water Resources |
| **DWRSIM** | DWR water project supply planning simulation model |
| **EDB** | ethylene dibromide, an agricultural pesticide |
| **EC** | electroconductivity |
| **EIR** | environmental impact report |
| **EPA** | Environmental Protection Agency |
| **ET** | evapotranspiration |
| **GIS** | geographic information system |
| **gpf** | gallons per flush |
| **gpm** | gallons per minute |
| **GWM** | ground water model |
| **HMWSD** | Henry Miller Water Storage District |
| **I–5** | Interstate 5 |
| **ID4** | Improvement District No. 4 |
| **KCWA** | Kern County Water Agency |

| | |
|---|---|
| **KDWD** | Kern Delta Water District |
| **KFE** | Kern Fan Element |
| **KFGWM** | Kern Fan Ground Water Model |
| **KWB** | Kern Water Bank |
| **M&I** | municipal and industrial |
| **MAF** | million acre-feet |
| **MCL** | maximum contaminant level |
| **mg/L** | milligrams per liter |
| μhos/cm | micromhos per centimeter |
| **MODFLOW** | U.S. Geological Survey Modular Three-Dimensional Finite-Difference Ground Water Flow Model |
| **MOU** | "Memorandum of Understanding between the Department of Water Resources of the State of California and Kern County Water Agency for Developing and Operating the Kern Water Bank," dated March 25, 1987. |
| **MSL** | mean sea level |
| **MWD** | Metropolitan Water District |
| **NRCP** | nonreinforced concrete pipe |
| **0&M** | operations and maintenance |
| **PG&E** | Pacific Gas and Electric Company |
| **ppm** | parts per million |
| **RCP** | reinforced concrete pipe |
| **RRBWSD** | Rosedale–Rio Bravo Water Storage District |
| **SCE** | Southern California Edison |
| **SRI** | Sacramento River Index |
| **SWAM** | Surface Water Allocation Model |
| **SWC** | State Water Contractors |
| **SWP** | State Water Project |
| **SWRCB** | State Water Resources Control Board |
| **TAF** | thousand acre-feet |
| **TDS** | total dissolved solids |

| | |
|---|---|
| **TWI** | Tenneco West, Incorporated |
| **USCE** | U.S. Army Corps of Engineers |
| **USFWS** | U.S. Fish and Wildlife Service |
| **USGS** | U.S. Geological Survey |
| **VCP** | variable circular plot |
| **WD** | water district |
| **WDRA** | Water Delivery Risk Analysis |

# APPENDIX A

## Kern Water Bank Land Use Advisory Subcommittee Recommendations for the Kern Fan Element

Several Land Use Advisory Committee and Subcommittee meetings took place between July and November 1990. In October, the subcommittees were asked to present recommendations and provide maps showing their reasonable land use "wish lists." What follows is a summary of those recommendations and land use wants.

***Water Resources.*** The primary purposes for purchasing the Kern Fan Element property were to provide land for ground water recharge and extraction facilities, partially correct overdraft conditions in the Kern Basin by removing land from cultivation and provide buffer area around recharge and extraction facilities to avoid adverse impacts on adjacent ground water users.

As one of the local benefits KCWA has proposed the creation of up to about 4,000 acres of additional recharge ponds to store Kern River flood waters. This is in addition to DWR's approximately 3,000 acres (at buildout) of SWP KFE recharge facilities (Figure A-1).

The Water Resources Subcommittee made the following recommendations:

1. The purpose of the KWB is to provide for the development of additional water supplies by local and State interests via the construction of recharge and extraction facilities. All other proposed land uses shall be subordinate to this purpose.

2. Proposed land uses other than for recharge and extraction should be permitted to the extent they are compatible with water recharge and extraction facilities.

3. The Land Use Plan for the Kern Fan Element should be prepared to conform with the ultimate plan of development of water recharge and extraction facilities, and should provide for phasing land uses in or out as additional phases of recharge and extraction facilities are developed.

4. Lands designed for development of recharge or extraction facilities should be maintained in their current land uses.

***Wildlife/Habitat Conservation.*** Given DWR's desire to use some of the KFE property to provide environmental mitigation for some of the SWP's past and ongoing activities, and the local demand for wildlife habitat conservation, KFE will provide some opportunities for preservation of remnant native habitat (plants & animals) and restoration/enhancement of disturbed (alteration by man) lands to native conditions.

The Wildlife Conservation Subcommittee has recommended the following:

1. Lands designated for management as natural habitats will be managed in a manner consistent with the approved recovery plans for San Joaquin Valley endangered species (both plants and animals).

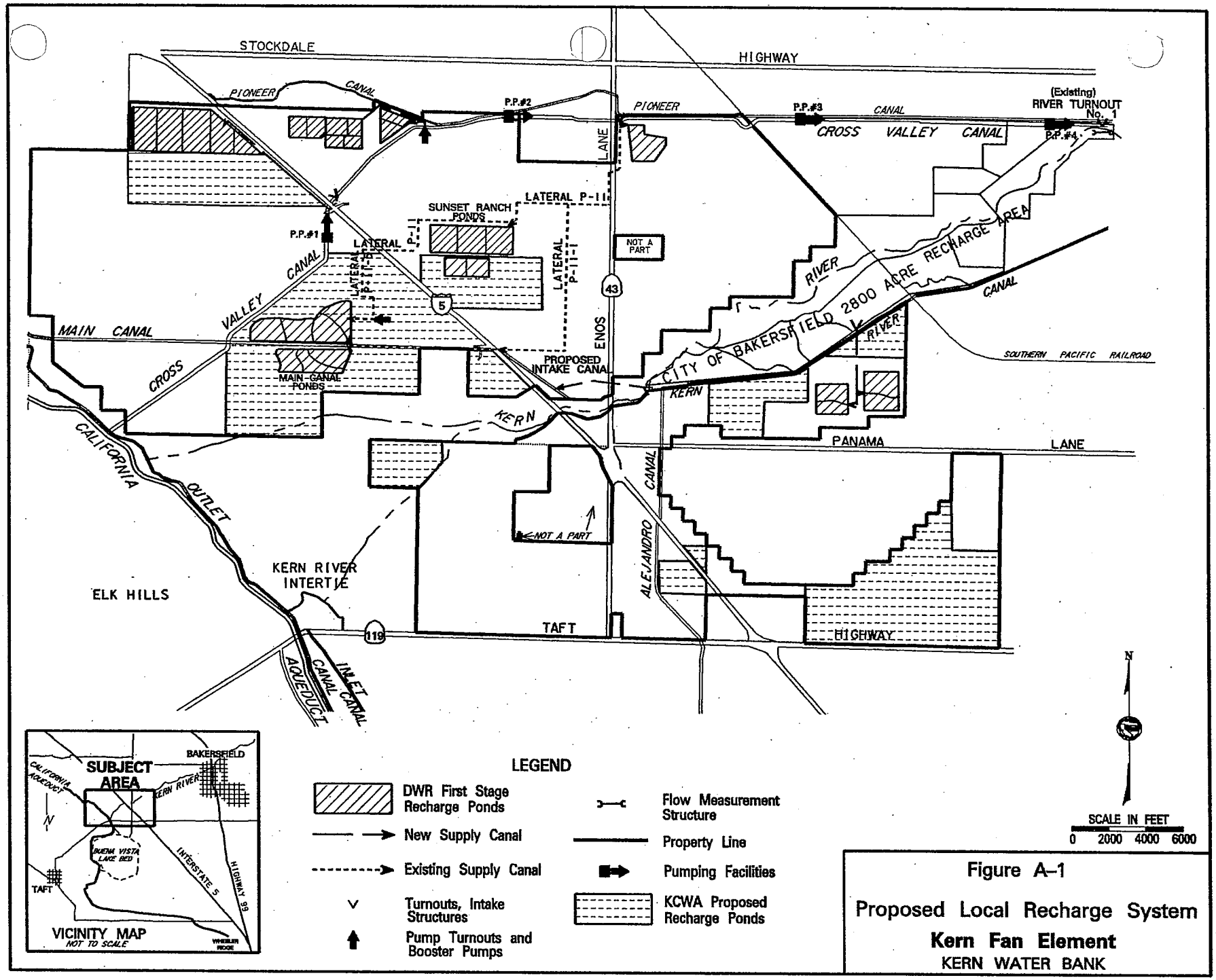



Figure A-1

Proposed Local Recharge System

**Kern Fan Element**

KERN WATER BANK

2. Land use planning will consider linking KWB lands with other adjacent natural habitats, thereby creating or extending wildlife corridors. Areas to be connected include the Kern River corridor, Tule Elk State Reserve, Metropolitan Bakersfield and Kern County Valley Floor Habitat Conservation Plan protection areas, City of Bakersfield Sewer Farm, and Naval Petroleum Reserve No. 1.

3. All KWB lands not required for water management shall be managed for the benefit of the plants and animals native to the area, especially listed species.

4. Land use should be consistent with extension of the Kern River Plan.

5. Recreational uses should be compatible with resource management objectives, emphasizing low-impact recreational uses (i.e., bike trail, bird watching, photography, etc.).

6. Any hunting on KFE lands shall be restricted to designated areas and subject to State and Kern County regulations.

7. Lands previously used for agricultural production will be rehabilitated/enhanced as habitat for native plants and animals.

8. All KFE lands south of the Kern River Corridor (6,000+ acres shown in Figure A-2) should be fully dedicated for restoration/enhancement of native plant and animal communities. Funding sources for restoration work would likely be available from Habitat Conservation Plan funds.

9. Private holdings within the proposed 6000-acre restoration area should be investigated for future acquisition and inclusion into the water bank/restoration project.

10. The management of wetlands and recharge sites should be consistent with goals of the Central Valley Joint Venture Project.

11. Water impoundment areas should be designed for both water storage and wildlife benefits.

Metropolitan Bakersfield Habitat Conservation Plan. The MBHCP provides an opportunity to link KFE conservation lands with future habitat conservation areas proposed by the MBHCP Steering Committee. The "primary goal of the MBHCP is to acquire, preserve and enhance native habitats which support endangered and sensitive species, while allowing urban development to proceed. . ." (Metropolitan Bakersfield Habitat Conservation Plan and Draft EIR, September 1990)

Conflicts between urban development and native species prompted the City of Bakersfield and Kern County to formulate a habitat conservation plan. Figure A-3 shows the location of potential local preserve acquisitions associated with the MBHCP.

Potential exists for local agencies to use MBHCP funds for restoration/enhancement of KFE lands to meet local habitat conservation requirements. Of course, issues of ownership, management and meshing of multiple use goals will have to be resolved before any conservation plans are implemented on the KFE property.

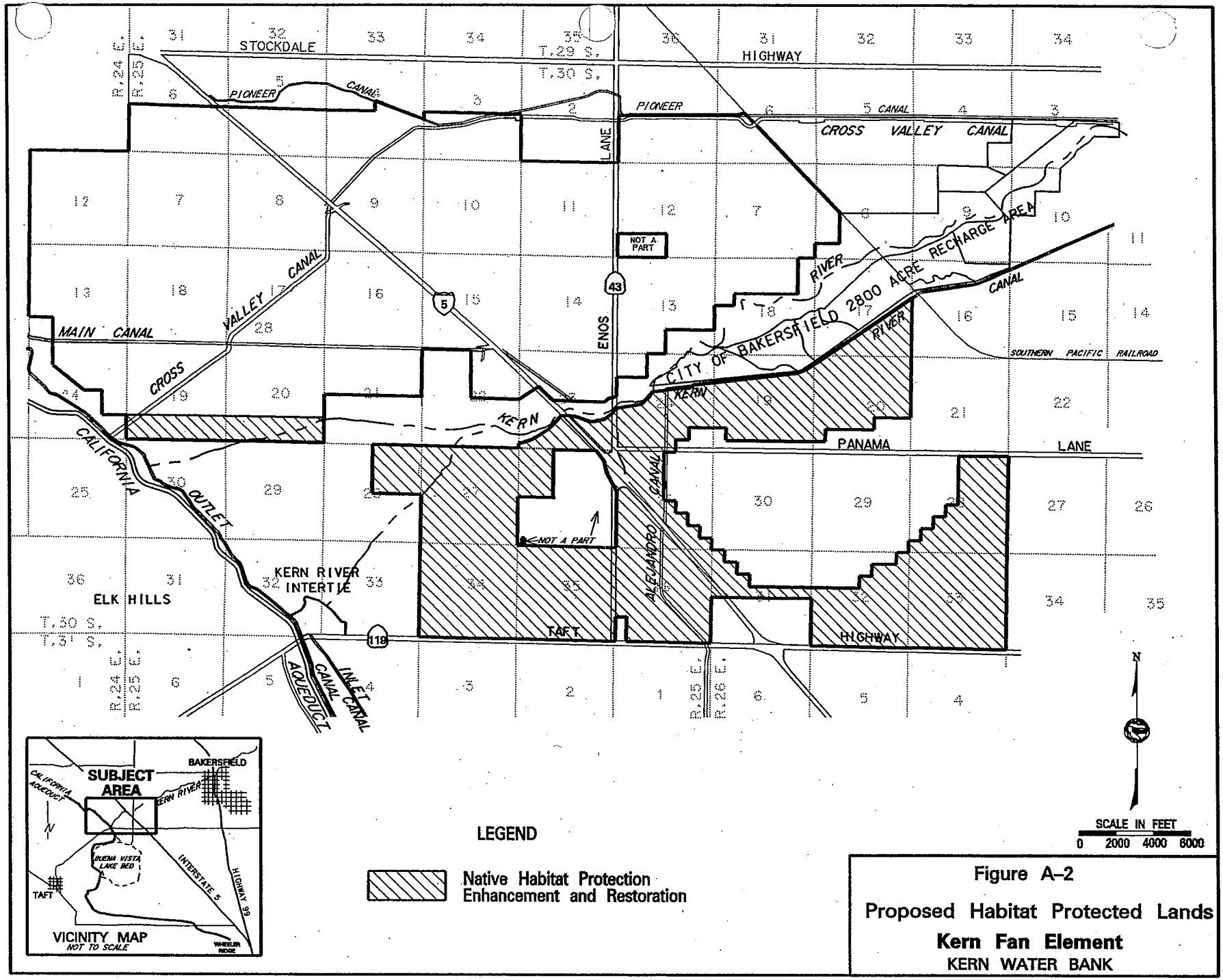
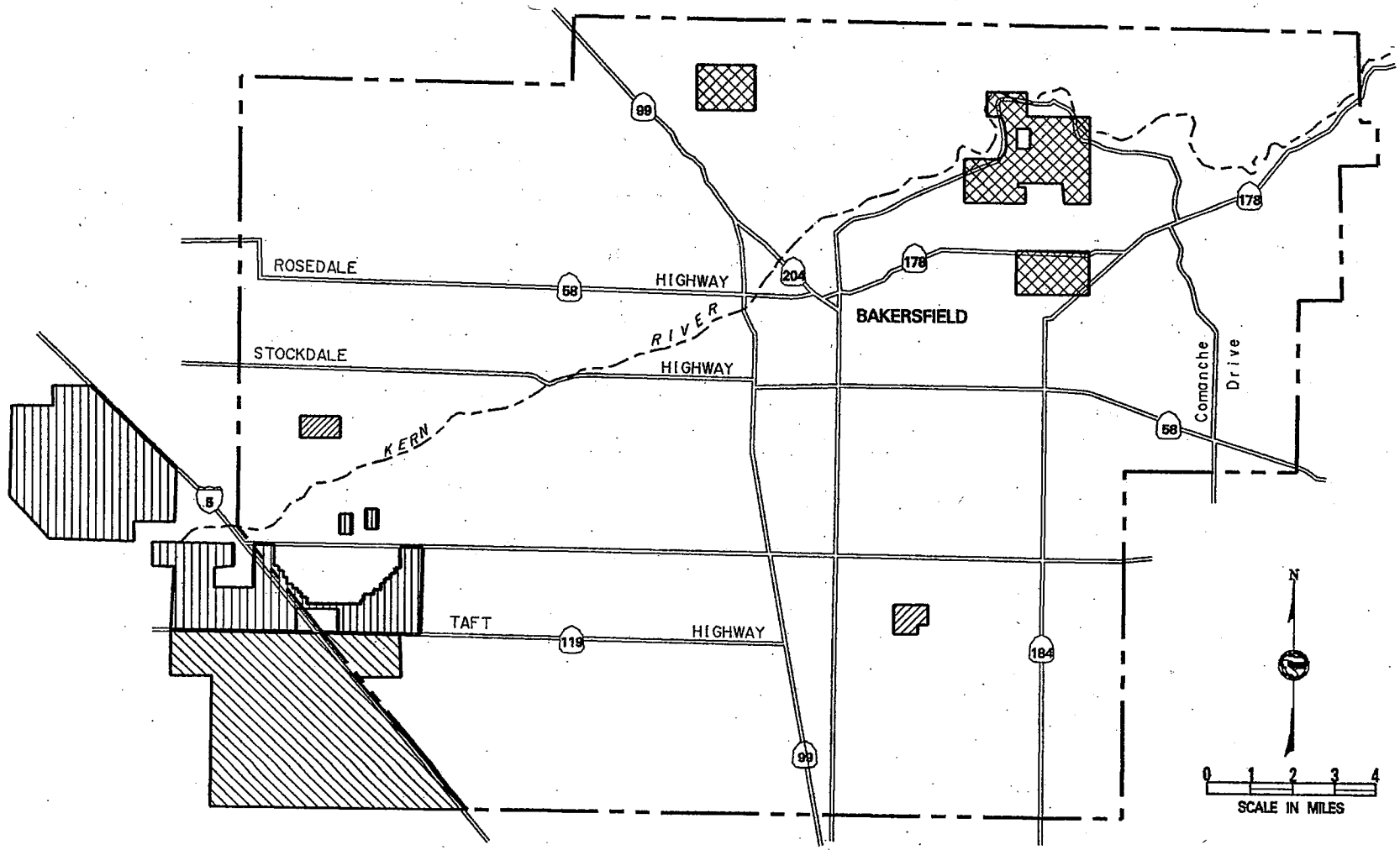



Figure A–2

Proposed Habitat Protected Lands

**Kern Fan Element**

KERN WATER BANK




LEGEND

- Specialty Plant Preserve
- Cactus Preserve Acquisition Areas
- South West Land Preserve Acquisition Area
- DWR Conservation Enhancement Priority Lands
- HCP Area Boundary

**Figure A-3**

**Metropolition Bakersfield Habitat Conservation Plan Local Preserve Acquisition Strategy**

**Kern Fan Element**

KERN WATER BANK

***Recreation.*** Recreation probably provides the most significant opportunity for compatible multiple land uses on KFE property. Provision of bicycle and equestrian trails and the creation of parks can probably be integrated with both wildlife conservation and water resources features and areas.

The Recreation Subcommittee has recommended several features (see Figure A–4), and goals including:

1. Proposed recreational lands will not threaten water quality and will remain within project related land use constraints.

2. Proposed recreational land uses will not disturb/destroy native habitat.

3. Proposed recreational uses will be of low impact to the Kern Water Bank and will be mutually compatible to the other proposed recreational uses.

4. Equestrian Trails shall be a designated riding and hiking paths that accommodate horseback riding and hiking through areas removed from vehicular traffic. The north side of the River, along the secondary floodplain line can most readily be adapted. Equestrian staging areas can be developed at appropriate intervals near points of trail access.

5. The Bike Path is a separate path following the old levee along the south side of the Kern River. The path shall also reach bicycle access to the Tule Elk Reserve and the Buena Vista Aquatic Recreation Area along the Intertie, Inlet/Outlet Canals. Public facilities shall be placed at appropriate intervals including points of access at Enos Lane, Buena Vista Road, Lake Buena Vista, and the Intertie at Taft Highway.

6. Non–motorized watercraft shall have controlled access to bodies of water as created by water recharge ponds. Water bodies shall have deep interiors and shallow edges. Examples of non–motorized watercraft can include canoe, row boat, small sail craft, etc.

7. Field Trial (Dog) Area/Upland Game Bird Habitat Restoration shall include controlled, unimproved access, parking and native vegetation.

***Agriculture.*** Though agricultural production is supposed to be phased–out by 1993, agricultural tenants of KFE lands have expressed interest in continuing some agricultural leases. The Agriculture Subcommittee has recommended the following:

1. Allow agricultural operations to continue on KFE property to some degree (Figure A–5).

2. Agricultural tenants could accept flood easements to accommodate local recharge of Kern River flood flows. Tenants would be released from lease obligations during the period their land is flooded.

3. Continued farming operations could provide for occasional spreading of recharge water as well as forage for some game species. In addition, at certain times of the year, agricultural lands could be used for dog field trails and training and for hunting (e.g., pheasant).

4. Tenants are willing to purchase surface water to help correct ground water overdraft.

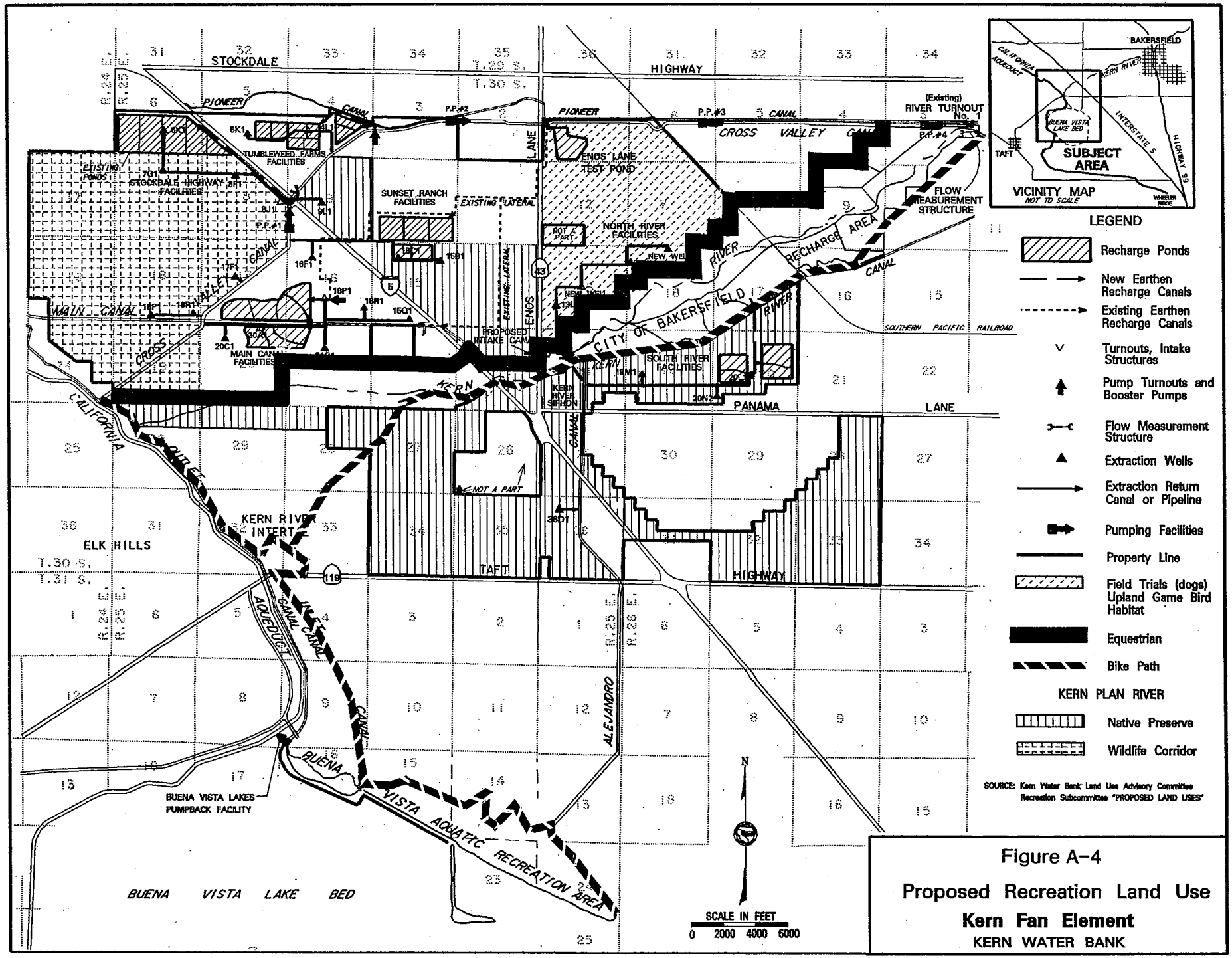



Figure A-4

Proposed Recreation Land Use

**Kern Fan Element**

KERN WATER BANK

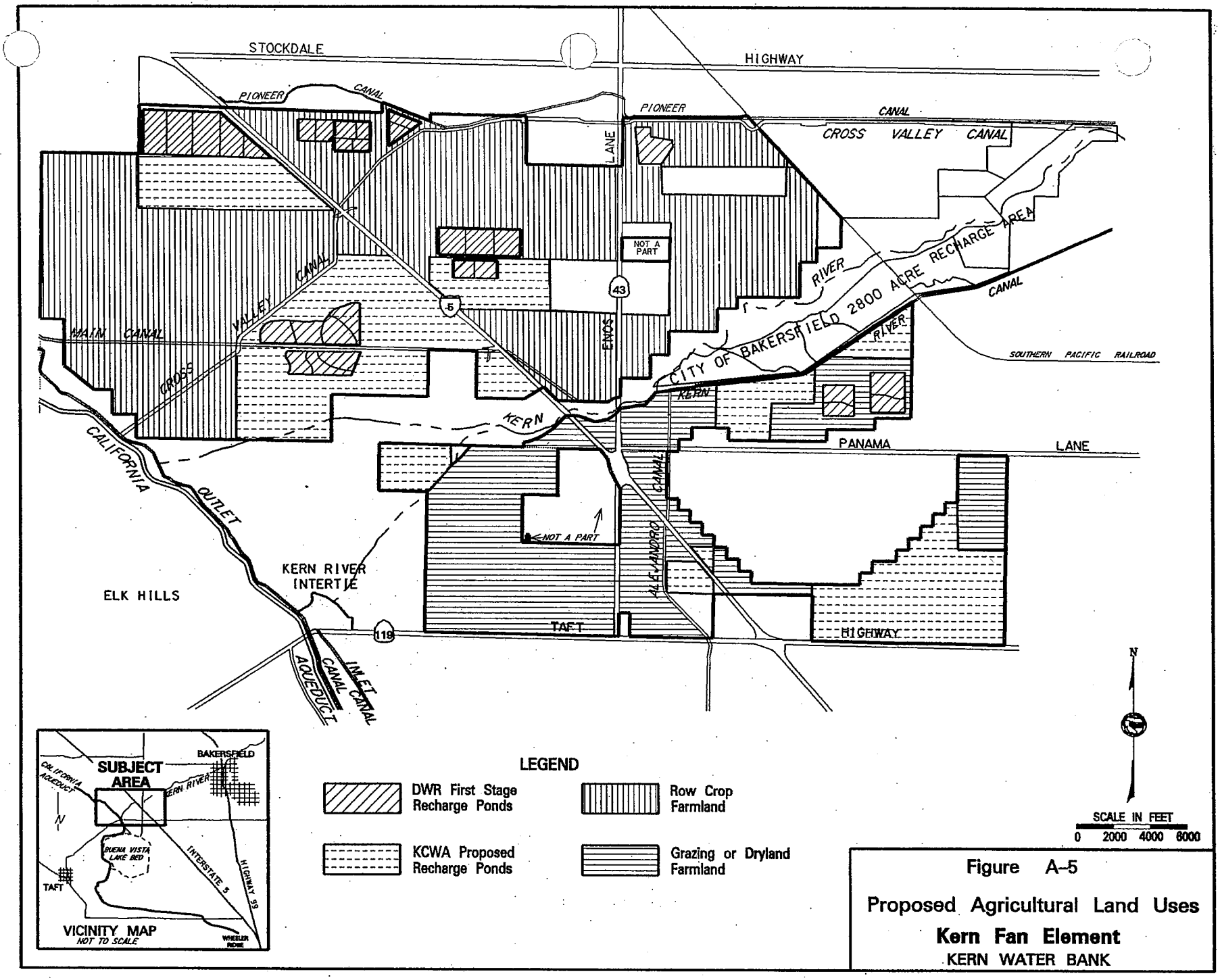



Figure A-5

Proposed Agricultural Land Uses

**Kern Fan Element**

KERN WATER BANK

5. Agricultural tenants may be able to extract ground water from contaminated wells for use on leased lands to remove (volatize) any contaminants.

6. Continued agricultural operations would allow for intermittent recharge and provide a positive cash flow from leased lands.

***Mineral Extraction and Utilities.*** Because ARCO owns the mineral rights to KFE lands, ARCO has specific rights to explore for and extract minerals over the entire property. The purpose for inviting ARCO to participate in the land use advisory process was to have ARCO advise land use committee/subcommittee members on the institutional requirements ARCO must meet to carry out its mining activities. In addition, the land use advisory process provides a forum for ARCO to determine how proposed land use changes might affect its ongoing and future oil activities.

PG&E, Southern California Edison and other utilities have utility transportation facility easements across much of the KFE property. All these utility features would have to be taken into consideration when developing recommendations on and designing future land uses.

# APPENDIX B

## Status of Potential Sensitive Plant Species for Kern Fan Element

| Species | | | | |
|---|---|---|---|---|
| **Scientific Name** | **Common Name** | **CNPS[1]** | **CDFG[1]** | **USFWS[1]** |
| *Atriplex patula* ssp. *spicata* | San Joaquin saltbush | 3 | - | C2 |
| *Atriplex tularensis* | Bakersfield saltbush | 1B | CE | C2 |
| *Atriplex vallicola* | Lost Hills saltbush | 1B | Special | |
| *Cirsium crassicaule* | Slough thistle | 1B | Special | C2 |
| *Caulanthus californicus* | California jewelflower | 1B | CE | FE |
| *Delphinium recurvatum* | Recurved larkspur | 1B | - | C2 |
| *Eremalche kernensis* | Kern mallow | 1B | Special | FE |
| *Eriastrum hooveri* | Hoover's wooly star | 1B | Special | FT |
| *Eriogonum gossypinum* | Cottony buckwheat | 4 | Special | C3 |
| *Layia leucopappa* | Comanche Point layia | 1B | Special | C2 |
| *Lembertia congdonii* | San Joaquin wooly-threads | 1B | Special | FE |
| *Opuntia basilaris* var. *treleasi* | Bakersfield cactus | 1B | CE | FE |
| *Pseudobahia peirsonii* | Tulare pseudobahia | 1B | CE | C1 |

[1]Status references:

**CNPS – Smith, J. P. Jr. and K. Berg. 1988. California Native Plant Society's Inventory of Rare and Endangered Plants of California, Special Publication No. 1, Fourth Edition.**

1B = Plants rare and endangered in California and elsewhere
3 = Plants for which more information is needed
4 = Plants of limited distribution
5 = Plants too widespread for listing

**CDFG – California Department of Fish and Game** Nongame – Heritage Program. Natural Diversity Data Base Special Plants List (February 1988).

CE = California endangered
CR = California rare
CT = California threatened
Special = Under consideration for future listing by CDFG

**USFWS – California Federally Listed Endangered and Threatened Species by County. August 30, 1990. (Sacramento Endangered Species Office)**

FE = Federally listed, endangered
C1 – Enough data are on file to support federal listing
C2 = Threat and/or distributional data are insufficient to support federal listing (= candidate species)
C3 = Too widespread and/or not threatened

# APPENDIX C

## Wildlife Species List

| Scientific Name | Common Name |
|---|---|
| **Reptiles and Amphibians** | |
| *Eumeces gilberti* | Gilbert's skink |
| *Uta stansburiana* | Side-blotched lizard |
| *Sceloporus occidentalis* | Western fence lizard |
| *Phrynosoma coronatum* | Coast horned lizard |
| *Cnemidophorus tigris* | Western whiptail lizard |
| *Croraphytus wislizenii silus* | Blunt-nosed leopard lizard |
| *Pituphis melanoleucus satenifer* | Pacific gopher snake |
| *Lampropeltis getulus* | Common kingsnake |
| **Birds** | |
| *Podilymbus podicops* | Pied-billed grebe |
| *Aechmophorus occidentalis* | Western grebe |
| *Ardea herodias* | Great blue heron |
| *Casmerodius albus* | Great egret |
| *Egretta thula* | Snowy egret |
| *Butorides striatus* | Green-backed heron |
| *Anas cyanoptera* | Cinnamon teal |
| *Carthartes aura* | Turkey vulture |
| *Elanus caeruleus* | Black-shouldered kite |
| *Circus cyaneus* | Northern harrier |
| *Buteo lineatus* | Red-shouldered hawk |
| *Buteo swainsoni* | Swainson's hawk |
| *Buteo jamaicensis* | Red-tailed hawk |
| *Buteo lagopus* | Rough-legged hawk |
| *Falco sparverius* | American kestrel |
| *Phasianus colchicus* | Ring-necked pheasant |
| *Callipepla californica* | California quail |
| *Fulica americana* | American coot |
| *Charadrius vociferus* | Killdeer |
| *Himantopus mexicanus* | Black-necked stilt |
| *Numernius americanus* | Long-billed curlew |
| *Calidris mauri* | Western sandpiper |
| *Larus californicus* | California gull |
| *Zenaida macroura* | Mourning dove |
| *Tyto alba* | Common barn owl |
| *Geococcyx californianus* | Greater Roadrunner |
| *Bubo virginianus* | Great horned owl |

| | |
|---|---|
| *Athene cunicularia* | Burrowing owl |
| *Calypte anna* | Anna's hummingbird |
| *Colaptes auratus* | Northern flicker |
| *Sayornis nigricans* | Black phoebe |
| *Tyrannus vociferans* | Cassin's kingbird |
| *Tyrannus verticalis* | Western kingbird |
| *Hirundo pyrrhonota* | Cliff swallow |
| *Corvus corax* | Common raven |
| *Turdus migratorius* | American robin |
| *Mimus polyglottos* | Northern mockingbird |
| *Toxostoma redivivum* | California thrasher |
| *Lanius ludovicianus* | Loggerhead shrike |
| *Dendroica coronata* | Yellow–rumped warbler |
| *Zonotrichia leucophrys* | White–crowned sparrow |
| *Agelaius phoeniceus* | Red–winged blackbird |
| *Sturnella neglecta* | Western meadowlark |
| *Icterus galbula* | Northern oriole |
| *Carpodacus mexicanus* | House finch |
| *Carduelis tristis* | American goldfinch |
| *Passer domesticus* | House sparrow |

**Mammals**

| | |
|---|---|
| *Didelphis virginiana* | Virginia opossum |
| *Sylvilagus audubonii* | Desert cottontail |
| *Lepus californicus* | Black–tailed jackrabbit |
| *Ammospermophillus nelsoni* | San Joaquin antelope squirrel |
| *Spermophilus beecheyi* | California ground squirrel |
| *Dipodomys heermanni* | Heerman's kangaroo rat |
| *Dipodomys nitratoides* | Tipton's kangaroo rat |
| *Peromyscus maniculatus* | Deer mouse |
| *Rattus rattus* | Black rat |
| *Canis latrans* | Coyote |
| *Vulpes macrotis mutica* | San Joaquin kit fox |
| *Procyon lotor* | Raccoon |
| *Taxidea taxus* | Badger |
| *Mephitis mephitis* | Striped skunk |
| *Lynx rufus* | Bobcat |

# APPENDIX D

# Measuring Economic Benefits of the Kern Fan Element

Water supply and demand reduction alternatives are considered ordinary and, in part, represent the actions that would be needed to cover potential shortfalls in dependable supplies listed in DWR Bulletin 160-87, *California Water: Looking to the Future,* November 1987.

The analysis presented in this appendix and discussed briefly in Chapter 6 is presented by region, including the South Coast Region, South Lahontan Region, Colorado River Region, San Francisco Bay Region, and Central Coast Region.

Local water management program options were divided into three categories:

- shortage contingency demand management and supply enhancement options;
- long-term demand management and supply enhancement options; and
- risk management.

Shortage management contingency options are measures implemented during shortages only and are intended to minimize the impacts of those shortages. Such measures include:

- use of banked local ground water;
- use of local carry-over storage;
- reduction of water deliveries to interruptible programs;
- purchasing water to augment normal sources of supply;
- instituting extraordinary water conservation measures; and
- rationing.

Long-term options considered include:

- waste water reclamation;
- desalination of brackish drainage and ground water;
- desalination of sea water; and
- development of water by importation.

Another long-term management strategy evaluated in this analysis is the explicit evaluation of risk with regard to the optimal level of use of long-term management options.

Economic benefits of the proposed KFE were determined by using the Economic Risk Model directly for the South Coast Region and State Water Project agricultural contractors in Kings and Kern counties. This is accomplished by using:

- the model results indirectly for the Central Coast Region, and
- current water costs to estimate willingness to pay for water in the San Francisco Bay and Sacramento regions.

# Attachment 4

# KERN WATER BANK AUTHORITY

5500 MING AVENUE, SUITE 490 BAKERSFIELD, CALIFORNIA 93309
(661) 398-4900

MAIN MENU

- KWBA Info

General Info
Location Map
Key Dates
DWR & the KWB
Board of Directors

- Recharge & Recovery
- Wildlife & Vegetation
- Conservation Bank
- Geology
- Archeology
- GIS / Mapping
- Photo Galleries
- FAQs
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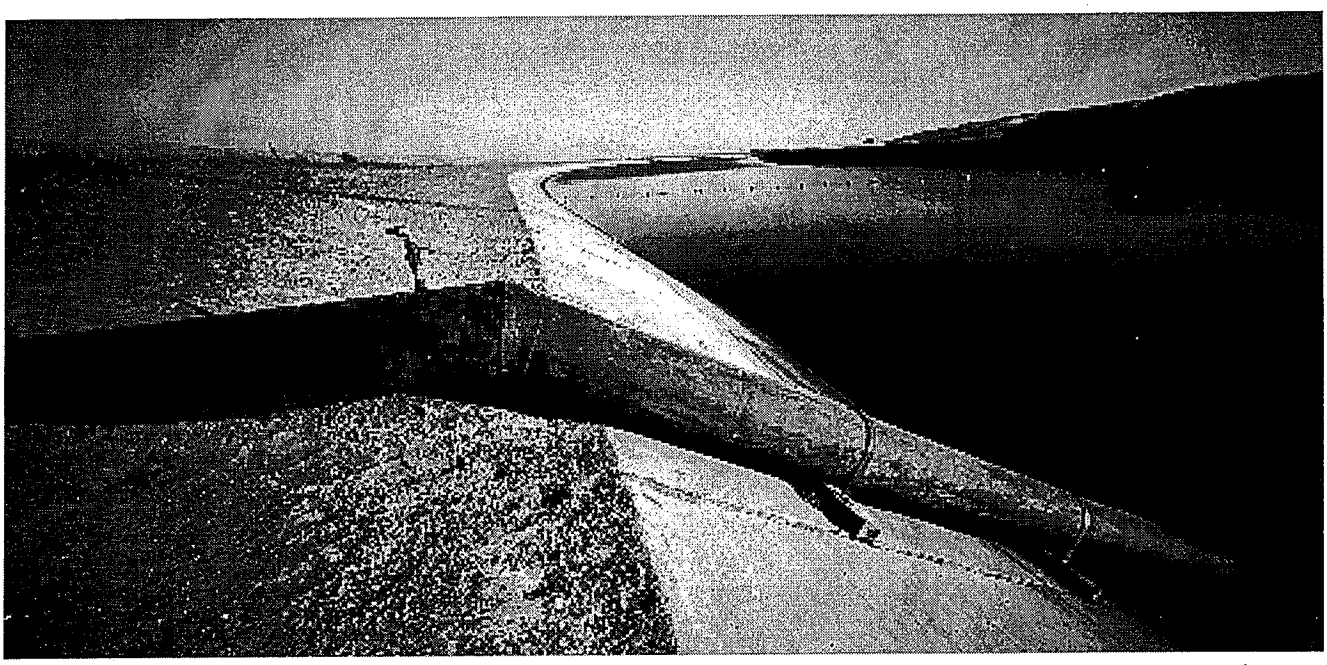
## The Department of Water Resources and the Kern Water Bank

In the early 1980s, the Department began exploring the feasibility of developing a SWP groundwater storage facility in Kern County. In 1988, Tenneco West, Inc. sold approximately 20,000 acres of land in the Kern Fan Element to the Department. The Department encountered many legal, institutional, and political impediments to implementation of a groundwater storage facility. SWP contractors also expressed concerns regarding their ongoing costs for feasibility studies and ownership of the Kern Fan Element property compared to their evaluations of the likelihood of realizing a functional groundwater storage program. In 1993, uncertainties regarding the proposed groundwater storage facility ultimately convinced the Department to halt feasibility studies and design work on the project.[i] The uncertainties included proposed revisions of Delta water quality standards and measures to protect threatened and endangered species, which affected the SWP's ability to pump water from the Delta for recharge at the Kern Fan Element. Expected changes in arsenic standards in drinking water also raised questions regarding the ability of the project to meet California Aqueduct pump-in standards.[ii] In addition to environmental issues, the Department and KCWA could not reach agreement on measures to comply with Water Code Section 11258, which required approval of local agencies for development of the groundwater banks. The Department concluded that these uncertainties and constraints on Delta pumping made development of an SWP groundwater storage facility in the Kern Fan Element infeasible.[iii] In 1994, the potential of the Kern Fan Element for groundwater storage remained unrealized, and DWR sought to divest itself of the property.

[i] California Department of Water Resources, Bulletin 132-93:11-12, 1995.
[ii] Draft DWR memo dated October 6, 1993.
[iii] California Department of Water Resources, Bulletin 132-94:26, 1996.

# Attachment 5



# Water Heist

## How Corporations Are Cashing In On California's Water

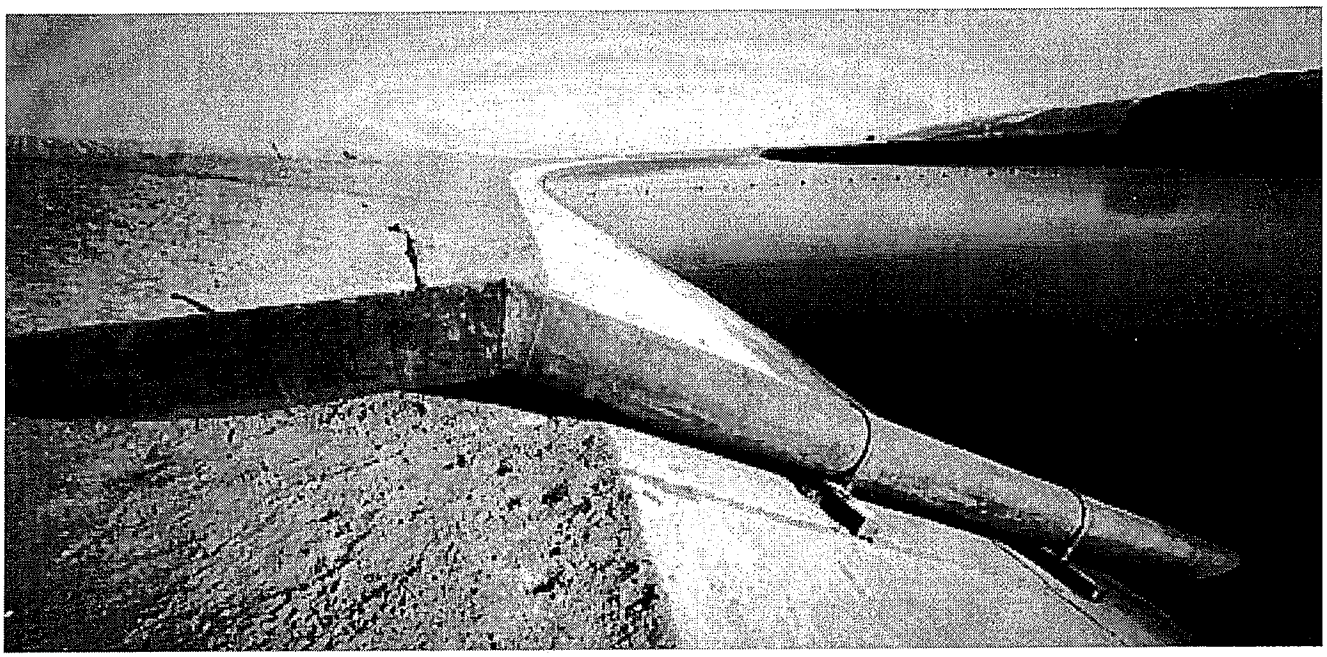
Public Citizen

WATER FOR ALL

CAMPAIGNING TO KEEP WATER AS A PUBLIC TRUST

California Office

*December 2003*



# Water Heist

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**Public Citizen** *is a national, nonprofit consumer advocacy organization founded by Ralph Nader in 1971 to represent consumer interests in Congress, the executive branch and the courts. We fight for openness and democratic accountability in government, for the right of consumers to seek redress in the courts; for clean, safe and sustainable energy sources; for social and economic justice in trade policies; for strong health, safety and environmental protections; and for safe, effective and affordable prescription drugs and health care. We have six divisions and two state offices.*

**The California Office** *Our campaigns protect the basics for life: food, water and democracy. We fight for safe and sustainable agriculture that provides locally-grown and nutritious food produced in a humane fashion. We advocate for democratic control and protection of public water resources in the face of international corporate strategies to privatize their ownership and distribution. And we continue to highlight how corporate-driven trade policy undermines environmental regulations, labor laws, and the democratic process.*

*Public Citizen is campaigning to protect universal access to safe and affordable drinking water by keeping it in public hands. Public Citizen does not believe that citizens benefit from privatization of their water and wastewater systems because the sale of public works to private companies can foster corruption and result in higher rates, inadequate customer service and a loss of local control and accountability.*

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**Acknowledgments** *This report was researched and written by John Gibler. Research assistance by Kevin Chapin and Logan Harris. The report was edited by Juliette Beck, Hugh Jackson, Erica Hartman, and John Gibler. The author would like to thank Carolee Kreiger, Michael Jackson, and Tim Stroshane for commenting on earlier drafts.*

**Photography** *Michael Bialecki—cover, pp. 2, 9 ,14, 15, 21, 22. John Gibler—pp. 1, 12, 16. Tom Price—p. 17. Richard Kadrey—p. 26.*

**Design** *Nicola Ginzler Design*

# Contents

Executive Summary ..... 1

Background: The Monterey Amendments ..... 5

The Kern Water Bank ..... 7

Who Controls the Kern Water Bank? ..... 9

Irrigating Sprawl ..... 12

Blaming the Environment ..... 14

The Napa Proposition ..... 15

Public vs. Private Property ..... 16

End of Game: Time for a Vibrant Water Democracy ..... 17

Get Involved ..... 19

Glossary ..... 20

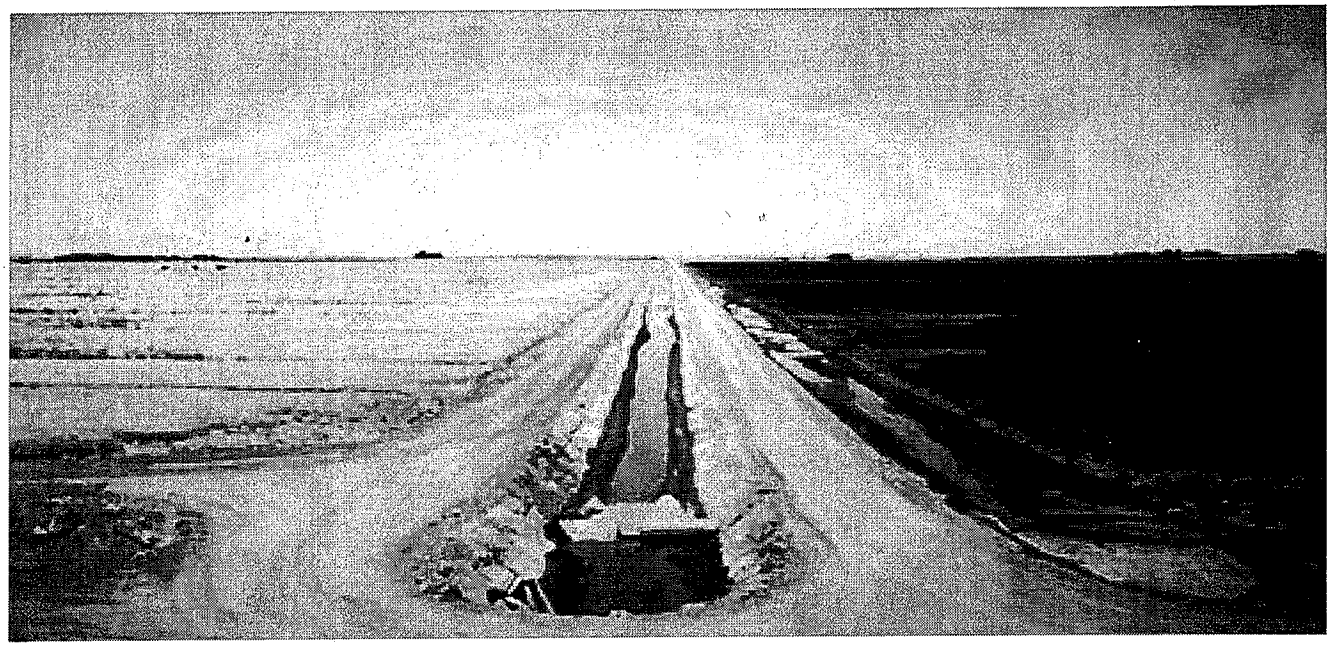
Appendix A—Historical Background ..... 21

Appendix B—Map of State Water Project ..... 24

Appendix C—Map of Water Districts, Kern County ..... 25

Appendix D—Roll International Corporation Holdings Diagram ..... 26

Endnotes ..... 27



*California's Great Central Valley receives between one and ten inches of rain a year. The diverted rivers sent south to be used as irrigation water provide the Midas touch that transforms the desert into the richest agricultural region in the world.*

## Executive Summary

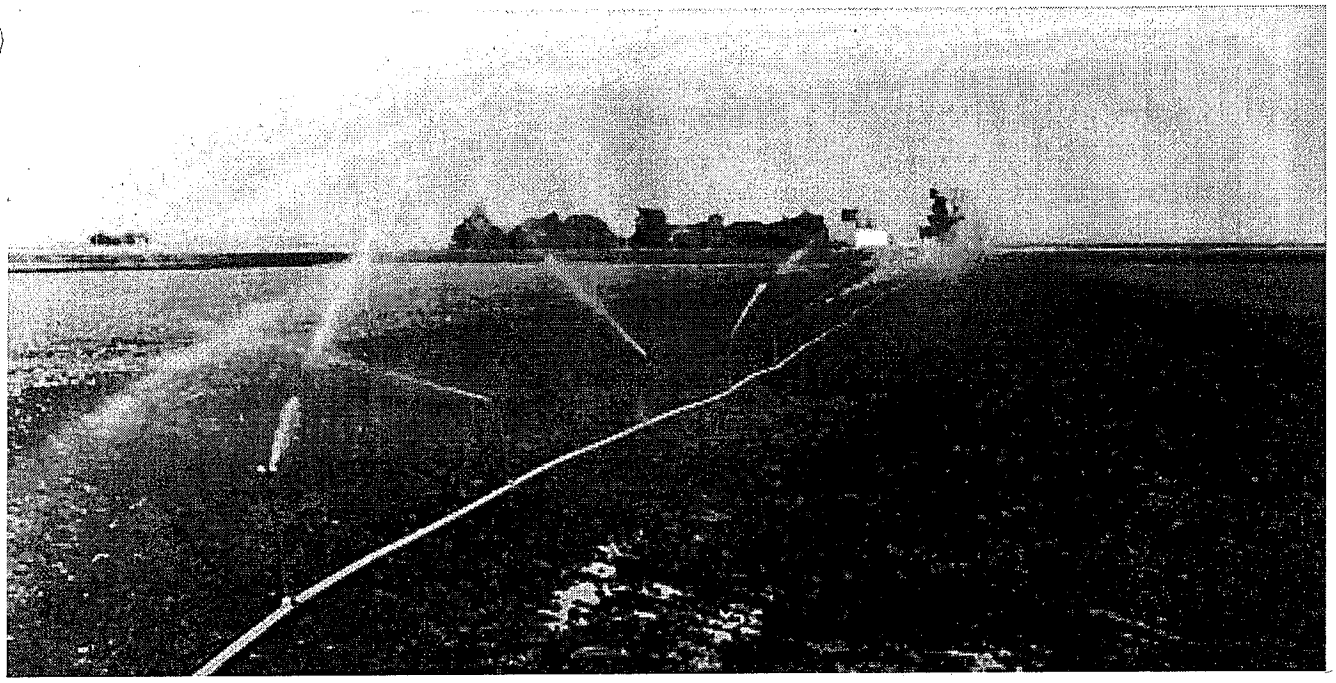
*California's Central Valley is one of the largest contiguous swaths of land on earth to have been so completely altered by human activity. Lake beds and wetlands have been drained and planted with cotton and almonds, rivers dammed and diverted over hundreds of miles from their sources, the air filled with such quantities of dust and pesticides as to become the most polluted in the country, and the dry semi-desert floor turned into the most productive agricultural region in the world. Now, after a century of such cosmetology, the Valley is about to get yet another makeover from a boom crop: sprawl.*

OVER THE PAST DECADE, a handful of the largest agribusiness and development corporations in the country have been rewriting California water policy in secret meetings to quench their thirst for unabated expansion and privatize the state's water supply. Displaying total disregard for the California State Constitution, representative democracy, and the environmental and social impacts of their actions, these players seek to "game" public water projects—much as Enron "gamed" energy deregulation. Their goal is to siphon as much of California's public water as possible to their corporate farms and "master-planned" cities in the desert while profiting from insider water sales.

In California state law, as laid out in the Constitution and the Water Code, water is a public good, held in trust by the state to ensure the greatest benefit to the public. In *Water Heist: How Corporations Are Cashing In On California's Water* we show how the public trust has been breached by an entrenched water plutocracy. The corporate interests that pervade the water districts that call the shots throughout the state are setting up insider water trading systems to facilitate the ease with which water flows to money. With direct corporate control over vital public water infrastructure—especially massive public water storage facilities—environmental protection and justice, urban renewal and smart growth face a desiccated future where profit rather than need dictates the destiny of California's water.

The abuses continue largely because they occur in closed meetings in hidden forms of government. Public Citizen aims to help cast the light of public scrutiny on the water deals taking place using the state's public water delivery system so that not just the CEOs of California have a voice in determining how our water is managed.

The water plutocracy includes some of the largest private agribusiness and development corporations in the country, who have created obscure and unaccountable water districts that act like "hidden government."



## Usurping Democracy: The Monterey Amendments

In 1994, the largest contractors with the California State Water Project (SWP)—the state's largest water delivery system—called the Department of Water Resources (DWR) into a closed meeting. The agreements that the SWP contractors and the state reached in that meeting led to a document known as the Monterey Amendments, named after the city where the meetings took place. These "amendments" to the SWP contracts included denying that the SWP delivers half of what the contractors say it does and effectively deregulating the SWP so that the contractors can sell contracts for precisely the half of the water that doesn't exist. Sound confusing? It is. Welcome to the world of "paper water."

In the same Monterey meetings, the state also agreed to give away an underground water storage facility that DWR spent $74 million purchasing and developing.

## State Giveaway of Essential Public Asset: The Kern Water Bank

The Kern Water Bank is an underground water storage facility—the largest of its kind—situated at the southern tip of the Great Central Valley, the region where the state delivers 80 percent of its surface water to industrial agriculture. The water bank is connected to the public canals and aqueducts that pipe water in from the northern, central and southern Sierra Nevada mountain range. The water bank can store about 1 million acre-feet of water and pump out over 200,000 acre-feet a year, according to official project descriptions.

The Kern Water Bank is an integral part of California's public water delivery system. It could store large amounts of water for times of drought or natural disasters such as fires or earthquakes. It could also provide a handful of private corporations with the keys to a virtual "switchyard" for controlling water deals between agribusinesses and real estate developers.

In 1994, DWR gave the Kern Water Bank to the Kern County Water Agency, which immediately signed it over to the Kern Water Bank Authority, a supposedly public entity comprised of a collection of water districts and one private company. The private company involved is a "paper company" with no listed telephone number or address: Westside Mutual Water Company. Westside is owned by perhaps the largest agribusiness in the United States: Paramount Farming Company.

## Who's Behind the Kern Water Bank? Roll International Corporation and Paramount Farming Company

Roll International Corporation—a Los Angeles-based holding company—is one of the largest privately owned companies in the world, and everything that Roll owns claims to be the biggest at what it does. Roll International owns the Franklin Mint, Teleflora, and a collection of

agribusinesses—all of which operate in three California counties—including Paramount Citrus, Paramount Farming, and Paramount Farms, Inc. The California Farm Bureau Federation wrote that together "these firms constitute the largest farming company in the United States." Roll is privately owned by Stewart Resnick, a Beverly Hills billionaire and major campaign contributor who gave over $350,000 to the Gray Davis Committee and the anti-recall groups between 2000 and 2003. Governor Davis chose Resnick to co-chair his agriculture-water transition team with the champion of the failed Cadiz groundwater banking scheme, Keith Brackpool.

Although the Kern Water Bank Authority oversees a vital water resource, its staff is tucked away in the offices of Paramount Farming Company, without so much as a sign on the door. Executives from Paramount, who created an almond and pistachio empire over the past two decades, said that they went into the water bank to secure a firm water supply for their crops. Local newspaper articles, however, quote Paramount's vice president, who presides over the water bank's board of directors, as saying "sales from the water bank were contemplated from the time the bank was acquired." In fact, the paper reports, Paramount is particularly interested in selling water to its parent company's home town: Los Angeles. Paramount executives have already had "early talks" with the Los Angeles Department of Water and Power about selling "an as-yet-unspecified amount of water."

The website of Paramount's Los Angeles-based law firm clearly boasts about how the law firm advised Paramount Farming Company to set up a mutual water company (Westside Mutual Water Company) to "own and operate" the Kern Water Bank. Paramount, it seems, has been planning for some time to harvest more than just pistachios and almonds.

## Irrigating Sprawl

California's population is expected to grow by 20 million in the next twenty years, and real estate developers are scrambling to get a hold of "secure" water supplies for their sprawling subdivisions. Public Citizen found a water sales contract between WV Acquisitions, a Roll International subsidiary whose president is also president of Paramount Farming Company, and Newhall Land and Farming Company, the largest developer in the state. Newhall has been taking advantage of the 1994 backroom deregulation of the SWP to go shopping for paper water contracts for the new "master-planned" city it plans to build in northern Los Angeles County. Such sales involve water supplies that are far from secure because they are based on allocated state water supplies: that is, paper water. Furthermore, this report raises the essential question: Should corporations like Paramount and Newhall be allowed to profit from buying and selling water that belongs to all Californians?

## Usurping Democracy, Again: The Napa Proposition

In July 2003, just months after the seven-year lawsuit challenging the Monterey Amendments by a coalition of environmentalists, public advocates, and one State Water Project contractor was settled, the participants in the Monterey meetings met again, this time in Napa. The agreement that resulted from these meetings—called the Napa Proposition—plans to further integrate the SWP and the federal Central Valley Project (CVP). Such integration will allow landowners, principally in the San Joaquin Valley and Southern California, to trade off the federal project's superior storage capacity and the state project's greater pumping capacity with one goal in mind: to continue pumping water to agribusinesses, developers, and water marketing barons in Southern California, unabated by either federal or state endangered species acts, water quality issues in the Delta, or the unmet needs of communities in the Central Valley that don't have access to clean drinking water.

## End Game: Water as Public Trust

California's public water utilities and resources are governed by a plutocracy—a select group of private corporations, individuals, and semi-public and public officials all working in tandem to "game" state water policy. They meet in closed sessions and rewrite public policy, tailoring their edits to the interests of monopoly-like agribusiness corporations and real estate developers. Is this a conspiracy theory? No. It is just business as usual.

The water plutocracy must be replaced with a vibrant water democracy.

Public Citizen strongly advocates returning the State Water Project to broad public use and oversight so that it can benefit all Californians, rather than only a select group of Los Angeles corporations. Water must be maintained as a public good, held in trust for broad and equitable use, *not* a commodity bought and sold by the highest echelons of the corporate elite.

We recommend the following concrete steps for accomplishing this goal:

**Return Kern Water Bank to Public Control**

Paramount and its Westside Mutual Water Company should never have been allowed to "own and operate the water bank." The privatization of this vital public resource should be reversed.

**Repeal the Monterey Amendments**

The Monterey Amendments should be repealed and the State Water Project contracts should be rewritten with an eye to water conservation and environmental restoration as well as the original stated purpose of the project: to reallocate California's water resources in an *equitable* manner.

**Eliminate Paper Water**

The Department of Water Resources continues to maintain on paper that the State Water Project can deliver almost twice as much as nature provides. The water "entitlements" of the twenty-nine State Water Project contractors should be re-drafted to fit the actual capability of the project to deliver.

**No Resale of State Water Project Water**

The individual contractors that receive state project water should not be allowed to profit from reselling that water, whether it is back to the state Environmental Water Account or to real-estate developers.

**Democratize Water and Irrigation Districts**

Water and irrigation districts that receive public water deliveries from the SWP should be transparent and accountable to the public. There should be elected, public representatives on the boards of such districts who would represent the non-landowning population affected by water policy decisions made most often in closed meetings.

NATURE PROVIDES ENOUGH WATER for California to meet all of its needs: to sustain water-efficient family farms and industries; to provide safe drinking water to present and future generations; and to restore and maintain California's much-abused environment. Nature provides enough water; that is, unless mismanagement and greed intervene and allow for the state's public water supplies to be manipulated for profit. Too much is at stake to let this water heist continue.

# Background: The Monterey Amendments

AFTER TWO YEARS of planning and negotiation, in 1988 the Department of Water Resources (DWR) purchased 19,900 acres alongside the Kern River.[1] DWR purchased the property for $31.4 million from Tenneco West Incorporated to build a subsurface reservoir to store State Water Project (SWP) water during years with above average rainfall.[2] On this property DWR first established the Kern Water Bank—an underground reservoir capable of storing a million acre-feet* of water. After conducting in-depth studies on the viability and potential environmental impacts of the project, DWR began putting in extraction pumps and building canals and conveyance facilities to connect the water bank to SWP aqueducts. All told, DWR spent $74 million on the project.[3]

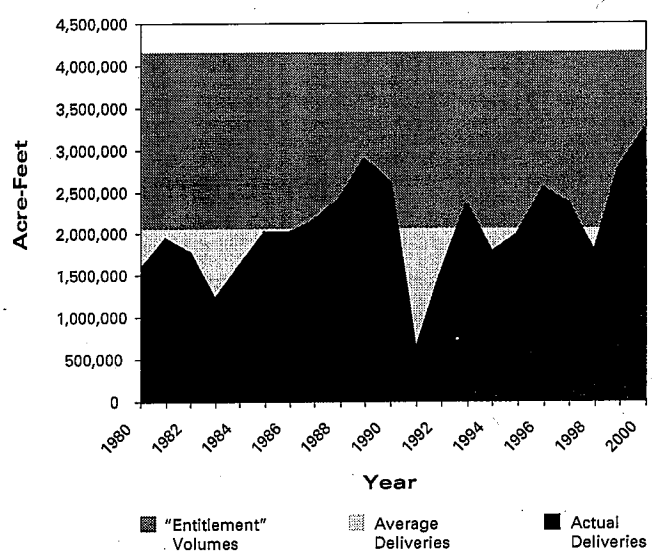
From 1987 through 1992 and again in 1994, California experienced drought years. During the drought DWR significantly cut back deliveries to its agricultural contractors. In 1991 and 1992, DWR operated a Drought Water Bank to pay contractors willing to forgo their water entitlements. DWR then delivered the purchased water to agricultural contractors and urban areas with the strongest demand. The Drought Water Bank was the state's first experiment with water banking.[4]

Following the drought, the Kern County Water Agency (KCWA) was preparing to take DWR to court for cutting back its water deliveries.[5] The state legislature created the KCWA in 1961 under the tutelage of Kern County's corporate farmers to buy SWP water and then sell it to the local districts where the landowners formed the boards of directors. As an intermediary, the Agency spread out the cost of SWP water through a countywide property tax, principally paid by the Bakersfield urban population. Both the intent and the effect of the KCWA were to generate water subsidies for large landowners.[6]

In 1994, rather than call DWR to court, water brokers in Kern County and a select group of other SWP contractors held a series of closed meetings with DWR to rewrite the contracts that govern water allocation for the entire State Water Project.[7]

The backroom deal that resulted—in which participants produced a document known as the Monterey Amendments, named for the city in which the meeting took place—made several fundamental changes to the SWP contracts, all propitious for the agribusiness and real estate interests represented by the attendees of the meetings.[8] The agreement withdrew, for example, a requirement that water allotments be scaled back to fit available supplies in the case of permanent water shortages or the inability of the project to deliver as originally projected.[9] The SWP contracts for 4.2 million acre-feet of water but can only deliver an average of about 2 million acre-feet annually.[10] This modification permits SWP contractors to buy and sell entitlements to water that does not exist, otherwise known as "paper water."[11] California water historian Norris Hundley describes the Monterey Amendments as "[a]n 'institutional mirage' encouraging the notion that California can somehow find all the water necessary for development into the distant future."[12]

**SWP Actual and Average Deliveries**
(1980-2000)




Source: Department of Water Resources Bulletin 132-90 and Bulletin 132-01.

It was also through the Monterey Agreement that DWR first gave the Kern Water Bank to the Kern County Water Agency, who then signed a joint powers agreement—enabling different districts to cooperate in their exercise of common powers—to form the Kern Water Bank Authority (KWBA). The KWBA is a joint powers authority consisting of two water storage districts (Semitropic Water Storage District and Wheeler Ridge-Maricopa Water Storage District), two

**An acre-foot is the amount of water necessary to fill an area of one acre to a depth of one foot, or 325,000 gallons. One acre-foot of water is roughly the amount that two families of four consume in one year.*

water districts (Dudley Ridge Water District and Tejon-Castac Water District), one special district (Kern County Water Agency), and one private company (Westside Mutual Water Company).

The Third District Court of Appeal ruled that, in 1995, DWR illegally passed off its responsibility under the California Environmental Quality Act of conducting an Environmental Impact Report (EIR) on the potential impacts of the proposed changes to the SWP contracts.[13] The DWR gave the task to the Central Coast Water Authority—one of the participants in the secretive Monterey meetings. The Planning and Conservation League together with the Plumas County Flood Control and Water Conservation District and the Citizen's Planning Association of Santa Barbara County challenged the validity of the EIR and the legality of the Kern property giveaway. The plaintiffs lost in the trial court but won a unanimous favorable ruling from the Third District Court of Appeal. They went into mediated settlement negotiations with DWR and its major contractors, finally reaching an agreement in May 2003.[14]

The Settlement Agreement requires DWR to prepare a new EIR on the Monterey Amendments. It also allows for the Kern Water Bank Authority's continued ownership of the water bank while the new EIR is in process.[15] Throughout the lengthy litigation and negotiation process, however, the changes wrought to California's water infrastructure and water politics continued unabated. Although the environmentalists were hoping to have the whole deal scrapped in court, for the first time in California history the agriculture and real estate magnates behind these deals began setting up a paper water trading system. Moreover, they turned the state's $74 million gift of the Kern Water Bank into "the switchyard for controlling the water market."[16]

Tim Stroshane, editor of the California water journal *Spillway: California Land, Water and People*, called the Monterey deal a "bloodless coup."[17] He wasn't exaggerating. The changes made in the closed meetings usurped participatory democracy and overhauled California's most vital public utility, tailoring it to the demands of agribusiness corporations and developers seeking to create and corner a subsidized water trading system.

*The water bank's administration—the Kern Water Bank Authority (KWBA)—is housed in Paramount's corporate office outside of Bakersfield. Paramount's vice-president also serves as chair of the Authority's board. There was no sign for the KWBA anywhere outside or inside the building when Public Citizen visited in July 2003.*

## The Kern Water Bank

"THINK OF THE BANK OF AMERICA, the way it operates with dollars, that's the way we operate with water," said Jonathan Parker, general manager of the Kern Water Bank Authority (KWBA) in Kern County.[18]

The Kern Water Bank claims to be the largest water banking project in the world. It can store a million acre-feet of water on a long-term basis and provide around 240,000 acre-feet per year for extraction.[19] To put this figure in perspective, 200,000 acre-feet, about 65 billion gallons of water, is the amount of water that would be transferred annually from the Imperial Irrigation District to the San Diego County Water Authority under the much contested deal between the two. The price tag on that deal now stands at $52 million a year.[20]

The water bank is located on the Kern River alluvial fan—the disintegrated rock deposited over thousands of years by the Kern River. According to the KWBA project description, the water bank works like this: "Water rapidly soaks down through the sand to fill in the voids between particles. When it is needed, water is easily recovered by high-flow wells."[21]

"Think of it like a bank," said Mr. Parker. "Participants have water. We're a nonprofit entity. What we do is provide a service. We store water at cost and then take water out of the ground, at cost. They pay us to provide that service in the least expensive manner. We operate only for participants."[22]

In 1994, the California State Legislature approved Assembly Bill 2014. Introduced in the Assembly on March 5, 1993, the bill was amended in the Senate on June 13, 1994, where the original language concerning water rights was entirely deleted and replaced with a single sentence authorizing mutual water companies to enter into joint powers agreements.[23] Also in 1994, DWR, the initial owner and developer of the Kern Water Bank, participated in the closed meetings in Monterey that led the state to transfer the property to the Kern County Water Agency, who called the meetings in Monterey.

The private company involved in the Kern Water Bank is Westside Mutual Water Company. Westside owns 48% of the bank. Westside is not a well-known company; in fact it does not have a listed telephone number or address. When asked about the participation of a private business in the otherwise public agency, the Bank Authority's staff responded that "Westside Mutual Water Company represents land holdings in other districts. They are not that different from a storage district. We don't see any difference in that."[24]

And whose land holdings does Westside represent? "Westside owns land, they represent their land," said Cheryl Harding, the Authority's administrator.[25]

"They're no different from a water district," Mr. Parker added.[26]

Westside Mutual Water Company is wholly owned by and operates exclusively for Paramount Farming Company, one amongst the cluster of agribusiness firms—all privately owned by Roll International Corporation—that together constitute what may be the largest agribusiness company in the United States.[27]

The KWBA staff appeared reluctant to mention the name "Paramount Farming." Such reluctance was peculiar considering where the interview took place: in the conference room of Paramount Farming Company's office on East Lerdo Highway, about 10 miles outside of Bakersfield.[28]

The KWBA leases its office space from Paramount. However, there is no sign either outside or inside the building to announce the offices of this supposedly public entity. Indeed, there is no distinguishing feature between the offices of KWBA employees and those of Paramount employees. Posters and maps published by the KWBA hang on the walls throughout the building. The Authority's geographical information systems (GIS) specialist works off of a lap-top in Paramount's GIS department.

"We lease space from Paramount because we're trying to do stuff on the cheap. We're not empire builders," Ms. Harding said.[29]

"We operate in the public, we serve a board of directors," added Mr. Parker.[30]

Ms. Harding then continued: "The 7 a.m. board meetings go on for a long time. Some people come, find it boring, don't come back. There's no smoking gun, just a meeting."[31]

**The Corporate Players behind the Kern Water Bank Authority**

| **KWBA Participant** | **Westside Mutual Water Company** (WMWC) | **Wheeler Ridge-Maricopa Water Storage District** (WRMWSD) | **Dudley Ridge Water District** (DRWD) | **Tejon-Castac Water District** (TCWD) | **Kern County Water Agency, Improvement District 4** (KCWA) | **Semitropic Water Storage District** (SWSD) |
|---|---|---|---|---|---|---|
| **Ownership** | 48.06% | 24.03% | 9.62% | 2.00% | 9.62% | 6.67% |
| **Corporate Connection** | William Phillimore: Chairman, KWBA Board of Directors; President, WMWC; ***Vice President, Paramount Farming Company*** | Dennis Mullins: KWBA Board of Directors; WRMWSD Board of Directors; ***Vice President, General Counsel, and Secretary, Tejon Ranch*** | Joseph MacIlvaine: President, DRWD Board of Directors; ***President, Paramount Farming Company*** | Dennis Mullins: KWBA Board of Directors; President, TCWD Board of Directors; ***Vice President, General Counsel, and Secretary, Tejon Ranch*** | See *Hidden Government*, p. 23 | ***Newhall Land and Farming,*** direct client, with 55,000 acre-feet of water storage capacity |

*The Kern Water Bank Authority (KWBA) is a joint powers authority consisting of two water storage districts (Semitropic Water Storage District and Wheeler Ridge-Maricopa Water Storage District), two water districts (Dudley Ridge Water District and Tejon-Castac Water District), one special district (Kern County Water Agency), and one private company (Westside Mutual Water Company).*

*Paramount Farming Company controls over 50 percent of the Kern Water Bank through Westside Mutual Water Company and Dudley Ridge Water District.*

*Another key player to keep an eye on is Tejon Ranch. Tejon Ranch, with 270,000 acres between Los Angeles and Bakersfield is "the largest contiguous expanse of land under single ownership in California," according to the company's website. Tejon Ranch, initially an agribusiness, plans to build a new town—even bigger than Newhall Ranch—with 24,000 houses, thus ushering in the trend of agriculture bowing to urban sprawl. Tejon's participation in the Kern Water Bank would allow them to store nearly twice as much water as their new town would require annually.*

Sources: Kern Water Bank Authority, *Project Description*, Undated; Water Association of Kern County, *Who's Who in Kern County Water*, <http://www.wakc.com/whoswho.htm>; Dudley Ridge Water District, *Board of Directors*, Undated; Tejon Ranch, *Historic Tejon Ranch*, <http://www.tejonranch.com/HistoricTejon/HistoricTejonRanch.html>; and Vic Pollard, "Land not only issue in the mix," *Bakersfield Californian*, 07 June 2003.

*Many industrial agriculturists in the Central Valley irrigate their almond orchards through routine flooding.*

## Who Controls the Kern Water Bank?

*Power veils itself. From the mystery of what it does, what it owns, and, above all, who it is, it assumes added strength.*

Gray Brechin, *Imperial San Francisco*

INFORMATION AVAILABLE to the public concerning Roll International Corporation is scant.[32] Roll is one of the largest privately owned companies in the world. Roll's 1998 sales were $1.57 billion.[33] Everything that Roll owns claims to be the biggest at what it does. Perhaps the most widely recognized company of the group is the Franklin Mint, "the world's largest direct marketer of collectibles."[34] In addition to the Franklin Mint, Roll International owns Teleflora, the nation's largest wiring service for flowers.[35]

Roll's agribusinesses—all of which operate in three California counties—include Paramount Citrus, the largest grower, packer and marketer of citrus in the country; Paramount Farming, the largest producer of almonds and pistachios in the country; and Paramount Farms, Inc., the largest pistachio processor and second-largest processor of almonds in the world. The California Farm Bureau Federation wrote that together, "these firms constitute the largest farming company in the United States."[36]

Roll International and its holdings such as Paramount Farming Company are Delaware corporations. Some of the perks of incorporating in Delaware include: incorporating without traveling to or living in Delaware; paying an annual corporate franchise tax as low as $50 regardless of income; and not paying a cent in income tax if you don't do business in Delaware.[37] Enron, for example, had 685 subsidiaries incorporated in Delaware.[38]

Roll International is owned and directed by Stewart Resnick. The Resnicks live in Beverly Hills, not Bakersfield. One visitor to the Resnicks' mansion commented that it was "like the Italian embassy but more tasteful."[39]

The Resnicks are active members in Los Angeles society. In the past few years they have received some of LA's highest awards such as the University of California Los Angeles (UCLA) Medal, the Duke Award and the City of Angels Award.[40] They give to numerous charities, universities, art museums and Democratic candidates, donating over $250,000 to the Governor Gray Davis Committee between 2000 and 2002 and $100,000 to anti-recall groups in June and September 2003.[41] In 1998, Davis, then governor-elect, appointed Stewart Resnick as co-chair of his "agriculture and water transition group."[42] Mr. Resnick's fellow co-chair was Keith Brackpool of the botched Cadiz water grab fame.

Paramount Farming Company has more than 5 million trees yielding billions of nuts a year. Growing, processing and marketing as one company, Paramount claims to be the largest vertically integrated supplier of pistachios and

almonds in the world.[43] The company currently has over 50,000 acres of pistachio and almond orchards in production in California. They also have the property holdings—and the plans—to expand into at least another 50,000 acres in the coming years.[44]

Almonds and pistachios are extremely lucrative crops. The California Farm Bureau Federation ranks almonds among California's top ten most valuable crops, generating $700 million in 2001 and over $1 billion in 2002.[45] Almonds are California's number one export crop, and also the top fruit and vegetable export crop in the United States.[46] Pistachios are not used as ingredients as often as almonds, making their demand significantly lower. Still, California's 2002 pistachio crop was valued at a solid $336 million.[47]

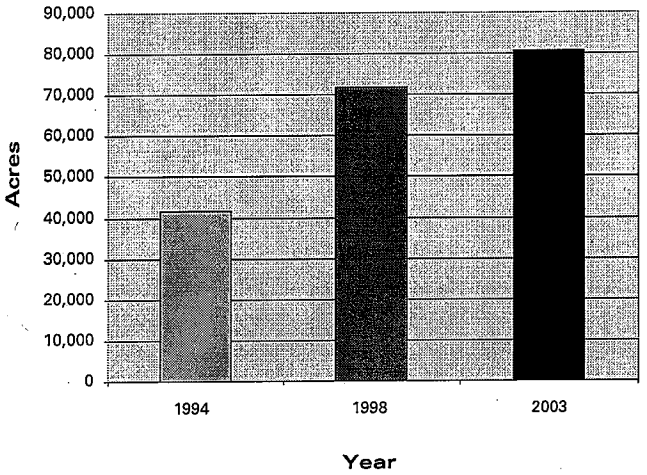
Paramount started buying pistachio, almond and olive orchards in 1986, after agricultural production dropped significantly in Kern County in the early 1980s.[48] Approximately 100,000 acres went out of production in Kern between 1982 and 1984.[49] Paramount and its associated companies, all held by Roll International, continued buying land into the 1987-92 drought that hit California agribusiness particularly hard. Roll purchased 12,000 acres of pistachio and almond orchards from Mobil Oil in 1986 and 77,000 acres of farmland from Texaco's central California agribusinesses in 1987.[50]

In 2000, Paramount bought most of Dole's citrus in California for $55 million, making it "the largest integrated grower, packer, and marketer of fresh citrus in the United States."[51]

In fact, while both the number of farms and agribusinesses and the total acreage of land in agricultural production in California dropped significantly throughout the 1990s, the Paramount group of agribusiness corporations doubled its acreage in cultivation from around 41,000 acres in 1994 to nearly 81,000 in 2003.[52] These figures come from analyzing Paramount's pesticide permits in Kern County alone. Paramount also has land holdings in Kings and Fresno counties.

Paramount has been steadily increasing its acreage and expanding production *against* the trend of the state's overall decrease in both agricultural acreage and production. Between 1992 and 1997 while Paramount was growing, California lost more than 3,500 farms.[53] Between 1998 and 2000, "90,000 acres of California farmland were lost to urbanization."[54]

**Cultivated Paramount Farms Land Holdings in Kern County**




*Paramount has doubled its acreage in production in Kern County over the past ten years.*

Source: Kern County Department of Agriculture, http://www.co.kern. ca.us/kernag/ftp/fileindx.html

Paramount's success is certainly a product of its agricultural technology and business organization.[55] Such success would not be possible, however, without water—indeed, enough water to satiate 100,000 plus acres of orchards depending upon year-round irrigation in a semi-desert.

Paramount and the KWBA's staff paint a picture of serious, risk-taking private enterprise saving the Kern Water Bank from the bungling hands of bureaucrats in Sacramento. In interviews they said repeatedly that DWR "couldn't get the project off the ground," and that the community prefers the water bank to be "under local control."[56] Paramount, a Delaware corporation, privately owned by one of the wealthiest residents of Beverly Hills, can hardly be considered "local."

The *Bakersfield Californian* also referred to the Kern Water Bank as a "local" asset. Under the headline, "Kern Water Bank will likely stay with county," the *Californian* describes the Kern Water Bank "property transfer" thusly: "One provision of the Monterey Agreement transferred ownership of the 20,000-acre water banking area along the Kern River bed west of Bakersfield from the state to a consortium of local districts, including KCWA."[57] The *Californian* does not mention Paramount Farming Company even though Paramount's water company, with 48% ownership, easily holds the largest share in the Kern Water Bank and Paramount's Executive Vice President, William D. Phillimore, is Chair of the Kern Water Bank Authority's

board of directors—a position that he is apparently able to carry out from his desk at Paramount.

Compare the *Californian's* take on the water bank acquisition with the following description provided by the Los Angeles law firm that represents both Paramount Farming Company and the Kern Water Bank Authority— Nossaman Guthner Knox & Elliott LLP:

> Paramount Farming Company was a key participant in the Kern Water Bank transaction, and Nossaman advised Paramount on all aspects of this transaction. The Kern Water Bank is a 20,000-acre property west of Bakersfield operated by the Department of Water Resources for groundwater storage. Pursuant to the Monterey Statement of Principles entered into by the Department and State Water Contractors in November 1994, the Department agreed to transfer the property. Nossaman advised Paramount regarding formation of a joint powers authority to own and operate the water bank, a mutual water company through which Paramount participates in the authority, relinquishment of entitlements, water rights, environmental issues and other issues regarding this transaction.[58]

Notice the language of intention: "Nossaman *advised* Paramount regarding the formation of a joint powers authority to *own and operate* the water bank."[59] Nossaman leaves little doubt that Paramount *planned* to acquire and control the Kern Water Bank.

Paramount grows pistachio and almond trees, some 5 million of them. Trees, unlike other crops such as rice or alfalfa, cannot be fallowed. In the semi-desert of the Southern San Joaquin Valley, no almond tree could survive without a constant supply of water. Kern County itself receives an average annual rainfall of less than six inches.[60]

The resource planning manager at Paramount Farming Company explained the motivation behind Paramount's participation in the Bank Authority as follows: "We're in the situation of growing almonds and pistachios without a firm water supply, so we went into the Kern Water Bank to secure a water supply."[61] He emphasized that Paramount's primary interest is in making a long term investment to grow their crops, and that "any sort of water marketing is very much secondary to crops."[62]

Should taxpayers and ratepayers foot the water bill for the self-described largest almond and pistachio producer in the United States to grow permanent specialty crops "without a firm water supply?" Is this the public's investment for a cheap supply of almonds? In 2001, Paramount's president, John McIlvaine, told the American Society of Farm Managers and Rural Appraisers that nearly 80% of California's almonds are exported—mostly to Western Europe and Japan—and that the almond industry is "on the move promoting foreign sales as its production grows larger and larger."[63] In fact, McIlvaine pointed out that California's tree nut exports have risen steadily over the past 15 years, a trend concurrent with Paramount's increase in acreage in production and the state's overall decrease.

## Irrigating Sprawl

*Water utilities exist primarily to nourish real estate, not people.*

Gray Brechin, *Imperial San Francisco*

INTERSTATE-5 IS LITTERED with roadside banners facing the oncoming traffic with messages such as "Food Grows Where Water Flows" and "Farm Water Feeds the Nation." Is Paramount feeding the nation? Which nation?

The *Bakersfield Californian* reported that Paramount is "most interested in selling water to Los Angeles."[64] Though they said that such sales were most likely not going to take place any time too soon, officials from the Los Angeles Department of Water and Power have already "had early talks with representatives of Paramount Farming Co. and other participants in the Kern Water Bank about possible purchase of an as-yet-unspecified amount of water."[65] In an interview with the *Californian*, Paramount's Bill Phillimore said "sales from the water bank were contemplated from the time the bank was acquired by Kern County water agencies in 1995."[66]

Other sales have already taken place. WV Acquisitions, one of Roll International's Delaware corporations, recently sold Newhall Land and Farming Company 5,099 acre-feet of its SWP annual water entitlement.[67] Newhall Land and Farming Company plans to build a "new city" of over 20,000 housing units and 3.58 million square feet of commercial space in bone-dry northwestern Los Angeles County. After years of controversy and lawsuits, the project was recently approved by the LA County Board of Supervisors and the Superior Court.[68]

Newhall has gone on a buying spree where the most cherished item on sale is SWP contract entitlements, or "paper water." These entitlements are contract promises, so to speak, from the state. During wet years, DWR will deliver at best most of the contracted water. During drought years, it might not deliver any at all. This is why the changes to the SWP contracts ironed out in Monterey are so important to the brokers in water: holding the state accountable for its original—undeliverable—contracts enables the contractors to sell "paper water" that won't be missed by their parched crops.

The Third District Court of Appeal that ruled against DWR in the Monterey Amendments case of 2000 declared that "Paper water always was an illusion. 'Entitlements' is a misnomer, for contractors surely cannot be entitled to water nature refuses to provide or the body politic refuses to harvest, store, and deliver. Paper water represents the unfulfilled dreams of those who, steeped in the water culture of the 1960s, created the expectation that 4.23 million acre-feet of water could be delivered by a SWP built to capacity."[69]

Corporations and water agencies are trading in "paper water" as a way of "gaming" the water in California to keep the severely over-stretched public water projects pumping water to the highest bidder. Though the contracts referred to as "paper water" do not correspond to deliverable water quantities—as noted in the Third District Court of Appeals

*PCL v DWR* decision—they function as a siphon to pull as much water as technologically possible out of the Delta. Real estate development corporations can use "paper water" contracts to get their projects approved without having a secure water supply. Once the projects are built, and the people about to move in, the corporations can use the contracts to demand water deliveries from the state. Such deliveries would most likely come through purchasing water rights from small farmers (potentially driving them off their land), not to mention continuing to neglect existing rural communities without access to safe drinking water and the deteriorating Delta environment.

Newhall is trying to purchase SWP water entitlements from Castaic Lake Water Agency.[70] Castaic, in turn, is attempting to double its SWP water entitlements by purchasing more from such water dealers as the Kern County Water Agency, and its member districts Berrenda Mesa Water District and Belridge Water Storage District.[71] Paramount's president and vice-president are presidents of the boards of directors of Berrenda Mesa and Belridge respectively.[72] Paramount is apparently thus well poised to sell even more "paper water" to the largest prospective developer in California.

Newhall also purchased 55,000 acre-feet of storage capacity in the Semitropic Water Storage District—one of the participants in the Kern Water Bank Authority.

With control over water storage facilities, the largest agribusiness companies like Paramount can hold on to enough water to do the impossible in a severely over-drafted groundwater basin: increase their production *and* sell to developers. Also, with development companies able to buy in directly to the storage facilities as well as purchase "paper water," they can argue before the courts that their water supply is reliable, on paper.

Lynne Plambeck, an activist with the Santa Clarita Organization for Planning the Evironment (SCOPE) and an ardent opponent of the Newhall Ranch project, said that control over storage facilities like the Semitropic Water Storage District and the Kern Water Bank is "a way of controlling water without actually owning water."[73] Private facilities can favor developers over farmers and large corporations over small businesses by charging less to those who store large amounts of water. One company or individual, Ms. Plambeck said, "can take up the storage facility with a lot of water, and then a drought comes along...They can corner the market with no public oversight, just like Enron."[74]

Private storage facilities are not subject to public oversight through laws such as the California Environmental Quality Act (CEQA), Ms. Plambeck said: "When the water goes into storage facilities in the Kern Fan, there is no oversight, no CEQA. The public only has a chance if there is a CEQA process."[75]

And what happens when the water isn't there? With the houses built and the new dwellers moved in, the developers will push for new dams and more pumping of water from the north to save the stranded residents from drought. The losers will be the same: the rural communities in the north and throughout the valley, the tax and ratepayers who ultimately have to pay for it all, and the environment upon which all Californians depend.

## Blaming the Environment

IN A SERIES OF ARTICLES written in 2002 on water issues in California, the *Sacramento Bee* profiled Kern County as "the hub of the water trade."[76] Dale Kasler, water correspondent for the *Bee*, reported that Kern water districts generated more than $100 million by selling water to cities throughout the state. In 2001, the Kern County Water Agency bought water from the SWP for $161 an acre-foot and then sold it back to the state's Environmental Water Account (EWA) for $250 an acre-foot, amassing $29 million. Paramount's Westside Mutual Water Company sold water it had previously "banked" in the Kern Water Bank to the EWA in 2000. All told, Kern Water Bank participants sold a total of 72,000 acre-feet to the EWA that year. Jim Nickel sold 10,000 acre-feet to the EWA for a total of $4.6 million, at "an eye-popping $460 an acre-foot."[77] What is even more "eye-popping" is that taxpayers throughout the state foot the bill for these sales.

The Environmental Water Account is a taxpayer-subsidized scheme that enables corporate agriculture to get around state and federal endangered species acts. It was created by CALFED, the state and federal collaborative effort to mitigate the continued devastation of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. CALFED is another step-child of the 1987-1992 drought that inspired the Monterey Amendments.

When the federal or state fisheries notify DWR of "high incidental intake"—when the pumps used to lift the SWP water uphill are sucking up too many endangered species—DWR slows down its pumping and monitors the amount of water *not* being pumped. DWR offers to purchase water from users south of the pumps and then deliver that water to contractors with higher value crops.[78] As a result, the water not pumped from the Delta is said to have been purchased for the environment. "Anytime by law exporters [SWP contractors] would have to stop pumping due to environmental or water quality conditions in the Delta, taxpayers buy replacement water for them," said Michael Jackson, a water attorney with the California Water Network who works with rural counties in Northern California.[79]

According to the chief of water transfers for the DWR, Jerry Johns, the EWA "is an example of a market remedy to help the environment."[80] The Public Policy Institute of California goes even further, saying that "[m]arket growth in the aftermath of the drought has been largely driven by environmental concerns."[81] Indeed, stronger environmental laws and advocacy have driven the largest SWP contractors to finagle market mechanisms to maintain undiminished SWP deliveries (secured by the "no net loss to exports" provisions for the EWA).[82]

The EWA enables market advocates to green-wash water sales. Advocates say that the program may be "a solution for creating more instream flows for endangered fish and habitat."[83] However, this is misleading. Agribusinesses and developers are not turning back water into the Delta. Rather, when their pumping threatens the continued existence of such species as winter-run salmon, the state pays to send them a quick fix.

## The Napa Proposition

IN JULY OF THIS YEAR (2003) the Federal Bureau of Reclamation, the California Department of Water Resources (DWR), and representatives from the largest agricultural and urban water districts in California—including the Westlands Water District, the Kern County Water Agency, and the Metropolitan Water District of Southern California—met in Napa in a series of closed, mediated sessions (by the same retired judge who mediated the Monterey meetings in 1994) to, yet again, restructure the state and federal water projects.[84]

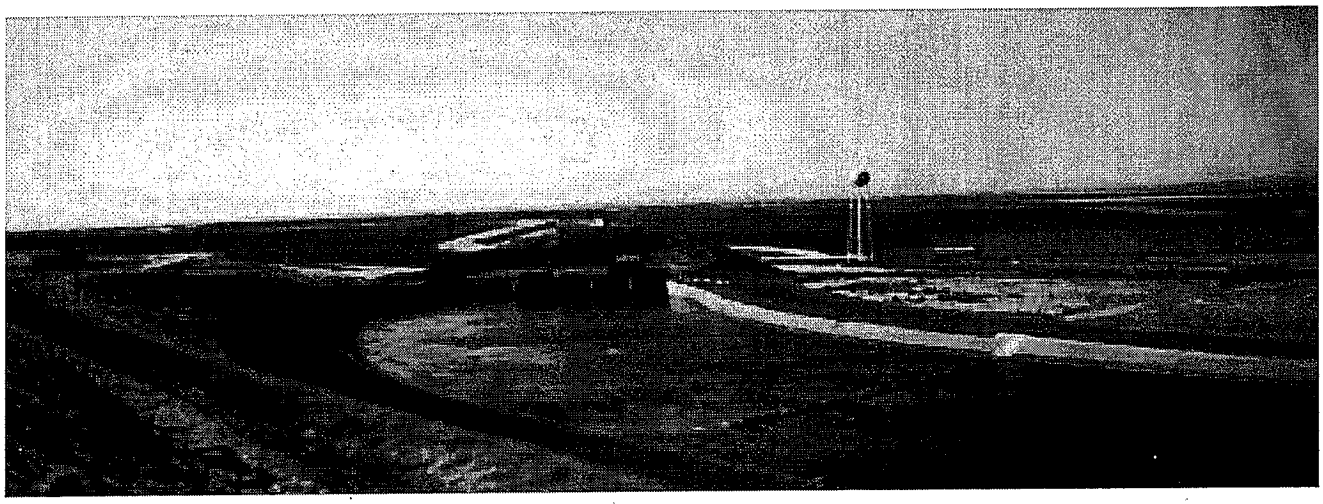
As noted by State Senator Michael Machado in a letter to the Editor of the *San Joaquin Record* on August 27, no "representatives of the Delta, environmentalists or anyone one else outside their small circle" were included in the meetings.[85]

The agreement that resulted from the meetings, called the Napa Proposition, plans to further integrate the SWP and the CVP. Such integration will allow landowners, principally in the San Joaquin Valley and Southern California, to trade off the federal project's superior storage capacity and the state project's greater pumping capacity with one goal in mind: to continue pumping water to agribusinesses, developers and water marketing barons in Southern California, unabated by either federal or state endangered species acts or water quality issues in the Delta.

Giving SWP contractors access to CVP storage capacity violates the later project's federal acreage limitations by enabling landowners, like Paramount, with over 100,000 acres to profit from federally funded infrastructure.

Increasing the SWP's pumping capacity violates the intent of the Delta restoration efforts and the federal and state endangered species acts by manipulating the technology to pump more water south at faster rates, ignoring the long-term effects of such levels of water exports on the environment.

The Napa Proposition would continue and greatly exacerbate the negative impacts of the Monterey Amendments, allowing the SWP and CVP to juggle water to maintain unsustainable exports for unsustainable development, unsustainable industrial agricultural practices and taxpayer-subsidized water sales among the state's largest landowners.



*The State Water Project's California Aqueduct is a vital public asset that must be administered as an integral part of California's public utilities for all Californians, not as private property for a few.*

## Public vs. Private Property

WATER MARKETS, much less insider trading regimes, are incompatible with California's constitutional protection of water as a public trust. The concept of private property that is essential to functioning markets cannot justly be superimposed on the state's public trust doctrine or the taxpayer-funded public water projects that gather, deliver, and store water. The state grants the right to *use* water, not to *own* it.

California state law considers water to be public property, not private. Article 10, Section 2 of the California State Constitution states:

> It is hereby declared that because of the conditions prevailing in this State the general welfare requires that the water resources of the State be put to beneficial use to the fullest extent of which they are capable, and that the waste or unreasonable use or unreasonable method of use of water be prevented, and that the conservation of such waters is to be exercised with a view to the reasonable and beneficial use thereof in the interest of the people and for the public welfare.[86]

The architects of the backroom Monterey and Napa meetings, however, have come up with a way to privatize the state's water resources in violation of the constitution. What advocates are now calling a water market is actually a public rip-off designed by and for large corporations in monopoly-like situations.

Moreover, this "market" both survives and thrives on overstating water supply so as to make millions in profit on "paper water." The imbalance between supply and demand does not stop there: paper water sales allow massive developers like Newhall to create and profit from demands that were previously nonexistent. By building housing developments in the desert where no natural water supply exists, developers will use the "build it and the water will flow" logic to create further unsustainable reliance on water diversion from the north. Thus, far from making "more efficient use of existing supplies through reallocation," the architects of California's water market have rigged a system where water continues to flow to money. This is not efficient, much less just.

Joseph Sax, in his landmark essay *The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention*, writes that, of the ideas that underpin the public trust doctrine in American law, the idea with the "greatest historical support holds that certain interests are so intrinsically important to every citizen that their free availability tends to mark the society as one of citizens rather than of serfs. It is thought that to protect those rights, it is necessary to be especially wary lest any particular individual or group acquire the power to control them."[87]

The state's giveaway of the Kern Water Bank and its backroom deregulation of the State Water Project have done just that: given the power to control California's water and the multi-billion dollar public projects that move that water to a particular group of private corporations.

*Local and statewide activists and union members fight to keep water utilities under public control in Stockton, CA.*

## End Game: Time for a Vibrant Water Democracy

PREDICTIONS ESTIMATE that California's population will grow by up to 20 million over the next 20 years. Such growth places strong demands on the state's limited water supplies, and makes the need for a publicly accountable, equitable, and environmentally sustainable system of water distribution all the more imperative. It will be possible to meet the state's water needs, but not if private interests such as Paramount are allowed to control—and profit from—key public water resources like the Kern Water Bank.

Under the public trust doctrine, California's water is held in trust for the people of California, our future generations and the environment. Thus, California's water supplies should be managed with the greatest level of public accountability and oversight to ensure that water is distributed where it is needed most, not where it is most profitable.

California's public water utilities and resources are governed by a plutocracy—a select group of private corporations, individuals, semi-public and public officials all working in tandem to "game" water policy in the state. They meet in closed sessions and rewrite public policy, tailoring their edits to the interests of monopoly-like agribusiness corporations and real estate developers. Is this a conspiracy theory? No. It is just business as usual.

The water plutocracy must be replaced with a vibrant water democracy.

To protect California's water from profiteering:

**Return Kern Water Bank to Public Control/ No More Public Giveaways**

The Department of Water Resource's decision to give away the Kern Water Bank should be immediately reversed. The state's giveaway of this valuable resource to allegedly "local agencies" was in violation of the public trust doctrine and the California Environmental Quality Act and should never have taken place. Local control of this resource has become tantamount to private corporate control. Paramount and its Westside Mutual Water Company should never have been

allowed to "own and operate the water bank," especially in light of their confessions to Bakersfield reporters that sales from the bank were in their plans from the very beginning. The privatization of this vital public resource should be reversed.

**Repeal the Monterey Amendments**

The Monterey Amendments—the backroom restructuring of the State Water Project—usurped participatory democracy in California water policy. The "amendments" also perpetuate and gravely exacerbate the environmental detriment and social injustices established by the water plutocracy that has gamed tax and ratepayers for decades to raise agribusiness empires on subsidized water deliveries. The Monterey Amendments should be repealed and the State Water Project contracts should be rewritten with an eye to water conservation and environmental restoration as well as the original stated purpose of the project to reallocate California's water resources in an *equitable* manner.

**Eliminate Paper Water**

The Department of Water Resources continues to maintain on paper that the State Water Project can deliver almost twice as much as nature provides. After decades in operation, it is clear that the paper contracts do not match reality. The water "entitlements" of the twenty-nine State Water Project contractors should be re-drafted to fit the actual capacity of the project to deliver. Such re-drafting is provided in the original article 18(b) that contractors struck from the contracts in the closed Monterey meetings. Local and regional land-use planning decisions should be re-evaluated to ensure that developments have not been permitted based on water supplies that do not exist.

**No Resale of State Water Project Water**

The individual contractors that receive state project water should not be allowed to profit from reselling that water, whether it is back to the state Environmental Water Account or to real-estate developers. Furthermore, after decades of overdraft, pollution, and watershed devastation, the California and Federal cooperative venture known as CALFED requires that water quality be restored in the San Joaquin Delta and the rivers that feed into it. Clearly, there is no "surplus" water to be traded among corporations. Paramount and other private interests must not be allowed to hoard water to sell at a later date.

**Democratize Water and Irrigation Districts**

Water and irrigation districts that receive public water deliveries from the State Water Project (SWP) should be open, transparent, and accountable to the public. Most water and irrigation districts that receive SWP water are controlled by large-landowners driven by their interest in paying as little as they can for as much water as they can get. With the twin goals of expansion and profit, landowners such as Paramount make decisions over public resources without being held publicly accountable. There should be elected, public representatives on the boards of such districts who would represent the non-landowning population affected by water policy decisions made most often in closed sessions and meetings.

The Kern Water Bank's accounting of stored and transferred water—where the water deliveries come from, and where they end up—should be immediately disclosed to the public. All water trades and transfers should be publicly recorded with full disclosure of the financial terms of the agreement, as well as the identities of the buyers and the sellers. All water delivery, storage and transfer deals should be made with full and meaningful participation of the public.

NATURE PROVIDES ENOUGH WATER for California to meet all of its needs: to sustain water-efficient family farms and industries; to provide safe drinking water to present and future generations; and to restore and maintain California's much-abused environment. Nature provides enough water; that is, unless mismanagement and greed intervene and allow for the state's public water supplies to be manipulated for profit. Too much is at stake to let this water heist continue.

# Get Involved

## About Public Citizen's *Water for All* Campaign

Public Citizen is campaigning to protect universal access to safe and affordable drinking water by keeping it in public hands. Public Citizen does not believe that citizens benefit from privatization of their water and wastewater systems because the sale of public works to private companies can foster corruption and result in rate hikes, inadequate customer service and a loss of local control and accountability.

## Public Citizen List Serves

Public Citizen maintains two water-related email lists. The Water for All list focuses on national and international efforts to protect water as a human right and includes action alerts, news articles, reports and the monthly newsletter of the Water for All campaign, Currents. The California Water for All list includes issue updates, campaigns action alerts, and Currents.

To subscribe to the Water For All list, send an email to cmep@citizen.org with "subscribe Waterforall" in the message.

To subscribe to the California Water for All list, send an email to cmep@citizen.org with "subscribe Waterforallca" in the message.

## Groups Working on Water Issues in California

**Alliance for Democracy**

1223 Sequoia Place
Davis, CA 95616
phone 530.758.0726
http://www.thealliancefordemocracy.org

**California Water Network**

808 Romero Road
Santa Barbara, CA 93108
phone 805.969.0824 fax 805.565.3394

**Center for Race, Poverty and the Enviroment**

1224 Jefferson St., Suite 25
Delano, CA 93215
phone 661.720.9140 fax 661.720.9483

**Community Alliance with Family Farmers (CAFF)**

36355 Russell Blvd.
Davis, California
phone 530.756.8518 fax 530.756.7857
http://www.caff.org

**Environmental Justice Coalition for Water**

1010 11th St., Suite 305
Sacramento, CA 95814
phone 916.341.0612 fax 916.341.0401
www.ejwatercoalition.org

**Santa Clarita Organization for Planning the Environment (SCOPE)**

P.O. Box 1182
Canyon Country, CA 91386
phone 661.255.6899, extension 2
http://www.scope.org

**Sierra Club, Angeles Chapter**

3435 Wilshire Blvd., #320
Los Angeles, CA 90010
phone 213.387.4287 fax 213.387.5383
http://angeles.sierraclub.org

**United Farm Workers (UFW)**

1010 11th St., Suite 305
Sacramento, CA 95814
phone 916.341.0612 fax 916.341.0401

# Glossary

**Acre-foot** An acre-foot of water is the amount of water necessary to fill an area of one acre to a depth of one foot, or about 325,000 gallons. One acre-foot of water is roughly the amount that two families of four consume in one year.

**Central Valley Project (CVP)** A Federal Bureau of Reclamation water project consisting of 20 dams and reservoirs, 11 power plants, and 500 miles of major canals. The project delivers about 7 million acre-feet of water annually.

**Department of Water Resources (DWR)** The California state agency that is responsible for managing the State Water Project.

**Entitlement** Also referred to as "Table A Allotment" in the Monterey Settlement, this is the volume of water contracted to State Water Project purchasers.

**Environmental Impact Report (EIR)** The study and report that is required under the California Environmental Quality Act for any large public or private infrastructure project as a means to assess the potential effects of the project on the environment.

**Environmental Water Account (EWA)** A component of the CALFED program, the EWA pays SWP water users when water deliveries are slowed down or reduced so that the SWP pumps decrease the amount of endangered fish species that get caught and killed in them.

**Joint Powers Authority** The agency created when two or more entities enter into a joint powers agreement. A joint powers agreement allows different (usually) public entities to join together in order to exercise their common powers toward a common objective.

**Kern County Water Agency (KCWA)** The KCWA was created in 1961 to distribute SWP water to Kern County water districts.

**Kern Water Bank** The largest underground water storage facility in the world. DWR spent $74 million purchasing the land, studying and developing the Kern Water Bank during the late 1980s-early 1990s. DWR gave the water bank to the KCWA in 1995.

**Kern Water Bank Authority (KWBA)** A Joint Powers Authority that consists of five water and water storage districts and agencies and one private mutual water company—Westside Mutual Water Company. Westside is in turn owned by Paramount Farming Company. The KWBA was formed immediately after DWR gave away the 20,000 acres that house the Kern Water Bank to the KCWA.

**Monterey Amendments** In 1994 DWR met in closed meetings with its largest contractors to rewrite the contracts that govern the SWP. At the end of the meetings the participants drafted a list of 14 principles which they called the Monterey Agreement, after the city in which the meetings took place. The changes to the SWP contracts that resulted from the Monterey Agreement are referred to as the Monterey Amendments.

**Paper Water** The original SWP contracts provided for an annual entitlement amount of surface water to be delivered to contractors upon availability. The SWP has never been able to deliver the contractors' full entitlements. The contractors, however, still treat the future expectations of the past as reality. One result of the Monterey Amendments was to enable contractors to buy and sell their entitlements. Hence, the entitlements, which stretch far beyond actual water deliveries, allow contractors to sell water that only exists on paper.

**Roll International Corporation** Roll International—a Los Angeles-based holding company, incorporated in Delaware—is one of the largest privately owned companies in the world. Roll International owns the Franklin Mint, Teleflora and a collection of agribusinesses—all of which operate in three California counties—that include Paramount Citrus, Paramount Farming, Paramount Farms, Inc. Paramount Farming is a member of the KWBA and owns 48% of the Kern Water Bank. Paramount also owns land in three of the other water districts and agencies that participate in the KWBA.

**State Water Project (SWP)** The SWP is a massive state water diversion and delivery project that comprises 662 miles of aqueducts, 19 dams with a combined surface area of more than 50,000 acres, 20 pumping plants, and ten energy plants producing about 6.5 billion kWh of energy annually. By 2000, Californians had paid more than $5 billion to build the project and another $11.9 billion to operate it and finance its debt.

**Water Bank** Water storage facility that operates like a bank. Participants or customers of the bank "deposit," or recharge, water and later "withdraw," or recover, water from their "account."

# Appendix A—Historical Background

## Water Flows Uphill to Money

CALIFORNIA IS A SEMI-DESERT. The mineral-rich soil of the Central Valley Region receives an average of 10 inches of rainfall a year, though far less falls in the southern portions of the Valley. Southern California's Imperial Valley receives 1 to 2 inches of rain a year. Yet, California's driest valleys are home to the richest agricultural region in the world.[88]

Step off to the side of Interstate 5 on a summer day, bend under a fence, and in the space of an inch you will see the sand turn into green fields. This is the unmistakable precision of industrial irrigated agriculture. Back on the interstate to the east and west, government-run irrigation systems douse crops with water. And as you proceed south on I-5 you will cross again and again one of the bond-funded arteries that makes this all possible: the State Water Project's California Aqueduct.

In California, agriculture consumes 77 percent of all usable fresh water.[89] Most of the water originates hundreds of miles north in the rivers bridled by the Oroville, Shasta and Trinity Dams. The state and federal projects that control the flow and destination of these rivers pipe and pump the water through a grid of nearly 4,000 miles of dams, aqueducts, canals, and reservoirs into the lands of the largest and wealthiest agribusinesses in the country.

By the 1930s, as a result of massive over-pumping, the earliest agribusinesses lowered the San Joaquin water table, the aquifer underlying the San Joaquin Valley, by as much as one hundred feet. Oak trees died and in places the valley floor itself dropped anywhere from 3 to 30 feet.[90] Fearing that they would run out of water within a matter of years, the largest landowners in the region began to push for publicly funded projects to pump water south from Northern California.

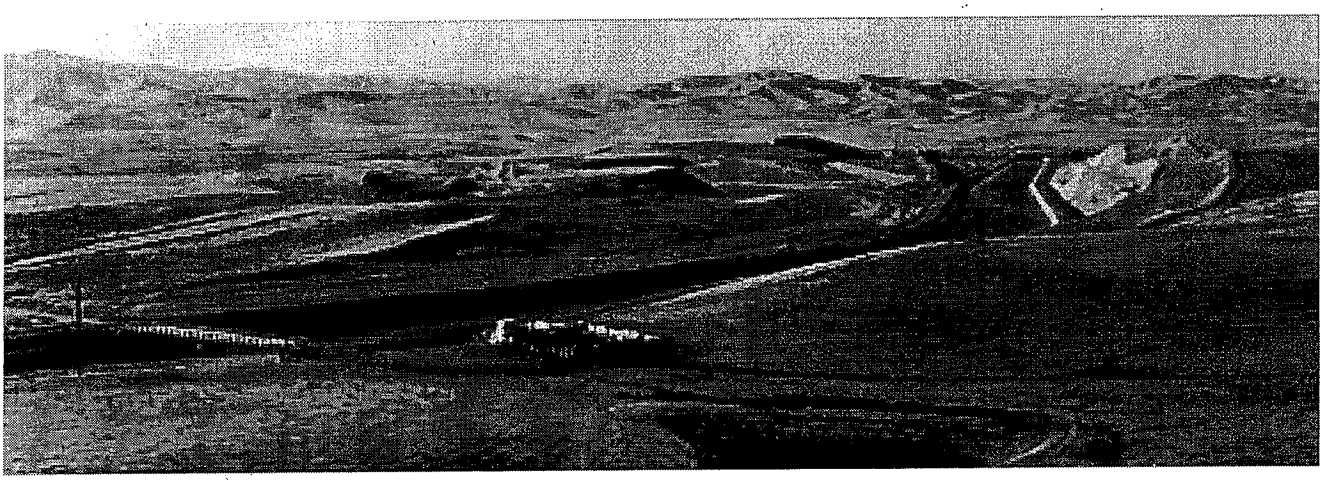
The Central Valley Project (CVP) began as a state initiative but failed for lack of funding until the federal government, and US taxpayers, came to pick it up in 1937. The CVP—the largest and most expensive public works project of its time—pipes some 9 million acre-feet of water from 20 dams and reservoirs to millions of city-dwellers and agribusinesses throughout the Central Valley and the urban San Francisco Bay Area.[91]

The Federal Bureau of Reclamation, the agency that administers the CVP, intended the CVP to break up land monopoly and promote small farms throughout the Central Valley. The project was subject to the 1902 Reclamation Law which put an acreage limitation of 160 acres—increased to 960 acres in 1982—on land eligible to receive CVP water for irrigation.

In 1978, when a federal team of investigators traveled into the largest district receiving CVP water—the Westlands Water District—they discovered that throughout the entire Westlands district there was not a single 160-acre farm. Through sleight of hand, family connections and sheer stubbornness, huge land owners failed to break up their farms and used the CVP water to build agribusiness empires.

California water historian, Norris Hundley, wrote that the CVP failed on both of its objectives: to combat monopoly and promote the family farm. Moreover, the result of the increasing power of landowners, Hundley wrote in *The Great Thirst*, was that "agriculture continued to concentrate in ever fewer hands. The number of farms over a thousand acres increased their combined property from 17.6 million acres in 1920 to 25 million acres in 1945. That trend... accelerated even more dramatically in the decades that followed. Thus did the family farm and local democracy fade from the California countryside."[92]

The California State Water Project (SWP), approved by the legislature in 1959 and by voters in 1960 made even greater



handouts to large growers in the state than the CVP. The state project was not subject to federal Reclamation Law, enabling large growers to expand production and increase acreage without the hassle of token acreage limitations. Moreover, the availability of state water as an alternative to federal water would make the Federal Bureau of Reclamation think twice before harassing the CVP recipients who were in "technical compliance" with the acreage limitations by deeding land to relatives or employees.[93]

The voter-approved bonds enabled the state to undertake the most ambitious water diversion project in history. The only way to get enough voters in Southern California to pass the statewide bond initiative—all assumed that Northern California voters would turn down a project to pay for pumping their water into the hands of Southern California landowners—was to lie about how much it would cost. Governor Pat Brown asserted that the project would cost about a billion dollars less than the estimated cost at the time.[94]

At present, the SWP comprises 662 miles of aqueducts, 19 dams with a combined surface area of more than 50,000 acres, 20 pumping plants requiring more than 60 billion kWh of energy annually, and 10 energy plants producing about 6.5 billion kWh of energy annually.[95] By 2000, Californians had paid more than $5 billion to build the project and another $5 billion to operate it and finance its debt.[96]

The Department of Water Resources (DWR) was created from 52 formerly independent state agencies to oversee the State Water Project and administer the delivery of water to the project's 29 contracting agencies.[97] These agencies range from the City of Yuba, 42 miles north of Sacramento, which had received a total of 10,260 acre-feet by 2000 to the Kern County Water Agency, which had received 26.3 million acre-feet by 2000.[98]

Kern County landowners advocated for both the CVP and the SWP as a way of improving the condition of the groundwater basin. However, with both projects, those very landowners increased the amount of acreage they held in production and thus exacerbated their overdraft of the basin.[99] Overdraft occurs when users pump more water out of the ground than nature can replenish or, in technical jargon, when extraction exceeds recharge. In Kern County, the increased overdraft of aquifers reached over 7 million acre-feet by the late 1970s.[100] According to the last *California Water Plan Update*, overdraft continues now at a pace of one million acre-feet a year.[101]

Marc Reisner, in his indispensable book, *Cadillac Desert*, described the SWP as "one of the country's foremost examples of socialism for the rich."[102] While urban water users bore the bulk of the expenses for the project, the corporate farmers got their water at bargain rates.[103]

In a 1981 report by the California Institute for Rural Studies, Don Villarejo writes that from the first SWP water deliveries in 1968 through to 1980, San Joaquin Valley contractors received 63% of the water delivered—almost entirely for agricultural irrigation—while mostly residential Southern California water users paid 70% of the costs of the project. "It is one of the many ironies of the SWP that those who get the most water pay the least, while those who get the least pay the bulk of the costs."[104] By the mid-1980s Norris Hundley estimates that Southern Californian water users were paying roughly $25 million a year in water subsidies for corporate agriculture in Kern County.[105]

According to DWR's Bulletin 132-01, by December 31, 2000, San Joaquin Area contractors had received 32.6 million acre-feet of water. They paid more than $1.3 billion for that water: an average of $40 an acre-foot. Meanwhile, contractors in Southern California received 22.5 million acre-feet of water

for a price of $6.65 billion. That makes SWP water $295 an acre-foot for Southern California's largely urban users.[106]

## Hidden Government

The federal and state water projects propelled the creation of "hidden" forms of government in California: the water districts and agencies through which landowners exercise control over the state's water.[107]

Norris Hundley notes Kern County's legacy of spearheading the effort to create special water districts for the management of the new water supplies coming from the CVP and SWP. In *The Great Thirst*, he writes that bringing back the concept of property-weighted voting—the allocation of votes based on a property owner's total land value—led to the creation of a variety of new water districts, the further concentration of agriculture in ever fewer hands, and the withering of local democracy. Such districts, he writes: "are ordinarily managed by boards of directors made up of a homogeneous, single interest body of people representing the larger water users and guided by a rigid set of goals: maximization of water use at minimum cost with little or no regard for the environment or for the welfare of the people of California."[108]

The Kern County Water Agency (KCWA) , for example, was created by the state legislature in 1961 under the influence of the county's corporate farmers to buy SWP water and then sell it to the local districts where the landowners again formed the boards of directors. As an intermediary, the Agency spread out the cost of the water through a countywide property tax, principally paid by the Bakersfield urban population. Both the intent and the effect of the Agency were to generate water subsidies for large landowners.[109]

The Kern County Water Association—not to be confused with KCWA, the *Agency*—was established and run by the most powerful landowners in the county. It advocated for the creation of the KCWA by the legislature. As Gottlieb and Fitzsimmons note: "The water association had three key goals: subsidies, to keep the price of water low enough to encourage new irrigation; elimination of acreage restrictions, that is, the 160-acre limit imposed—at least in name—on certain federal projects such as the CVP; and creation of a contracting agency on a countywide basis to secure the tax base of the entire county."[110]

The arrival of SWP water through the California Aqueduct set off a "speculative spiral" in Kern County where landowners rushed to expand their acreage and set up water districts to contract for SWP water through the KCWA. "A handful of landowners dominated most of the key water districts affiliated with KCWA, and these districts, in turn, dominated the agency."[111]

KCWA now has 13 member "units" that together contract for an annual total of 1,000,949 acre-feet of SWP water. Agricultural water users hold 88 percent of the contracts while municipal and industrial users hold 12 percent.[112] Corporate farmers in Kern however, have been receiving *more* water than they contract for since the beginning of the SWP, owing to the questionable concept of "surplus" water.

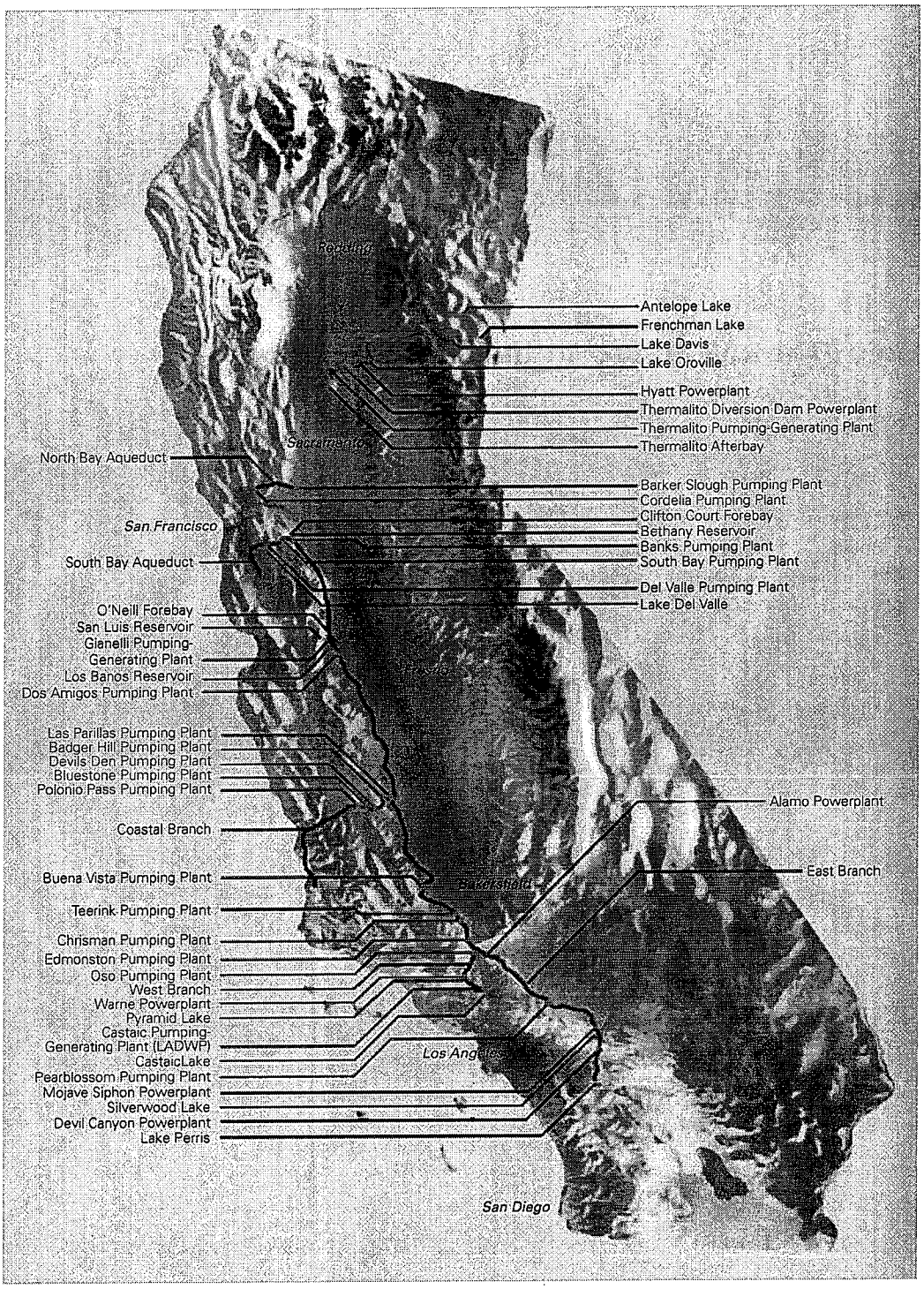
The SWP has never delivered the full 4.1 million acre-feet of water set forth in the original contracts. Average annual deliveries float at around half that amount. How then could there be "surplus" water?

The Metropolitan Water District of Southern California (MWD)—often referred to as The Met—is the largest water agency in California. MWD is a water wholesaler providing "supplemental" water to 27 clients, which in turn serve an area of over 5,000 square miles with a population of 15 million.[113] MWD is also the largest contractor with the SWP, contracting for over 2 million acre-feet of water.

MWD initially opposed the SWP, but signed on four days before the 1959 election.[114] MWD and the Kern County Water Agency came into conflict early on during negotiations over how to distribute the costs of the SWP. The agreement they reached enabled Kern to purchase water at discounted rates. MWD also had to pay for that same water creating "implicit subsidies for the agricultural agency [KCWA] which, by extension, penalized the district [MWD]."[115]

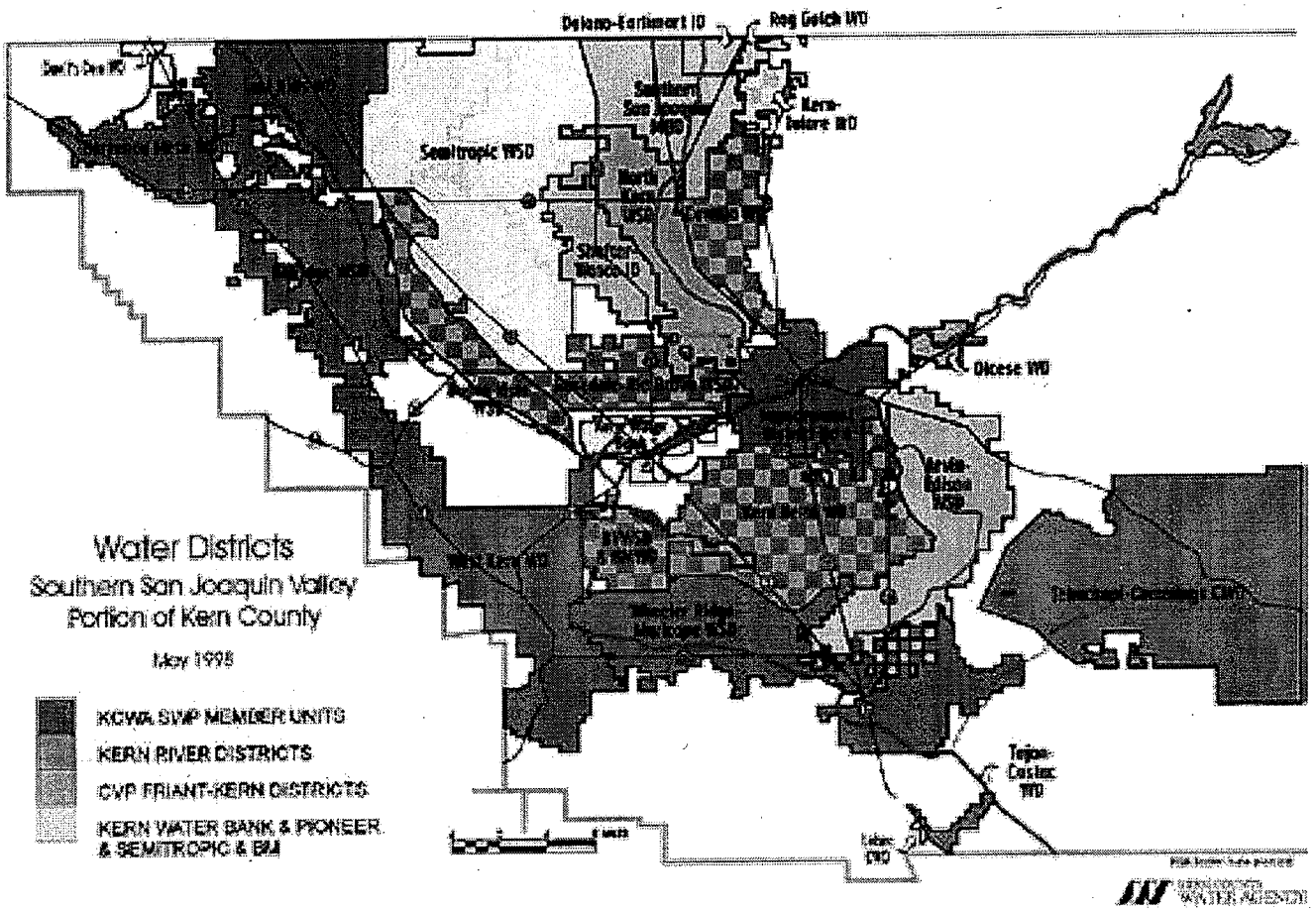
Kern landowners reaped the benefits instantly and have continued to do so ever since. For example, in 1979, KCWA entitlements had increased to 516,300 acre-feet, the agency purchased another 524,247 acre-feet of "surplus water" beyond their contract entitlements. That contracted water cost KCWA member agencies more than $15 million (or about $29 an acre-foot) while the same amount of "surplus water" only cost $2.3 million (or about $4 an acre-foot). This reduced the overall cost to $17 per acre-foot.[116]

# Appendix B—Map of State Water Project




*The SWP comprises 662 miles of aqueducts, 19 dams with a combined surface area of more than 50,000 acres, 20 pumping plants, and ten energy plants.*

# Appendix C—Map of Water Districts, Kern County



## Appendix D—Roll International Corporation Holdings Diagram

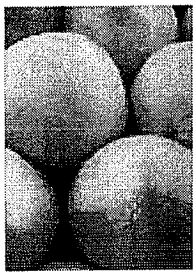
Stewart Resnick

Roll International Corporation

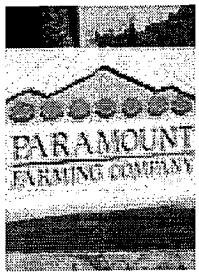
Franklin Mint

Teleflora

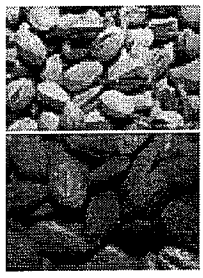
Paramount Citrus



Paramount Farming Company




Paramount Farms, Inc.



Westside Mutual Water Company

Kern Water Bank Authority, 48%

# Endnotes

1 California Department of Water Resources, *Overview, History, and Milestones* <http://www.dwr.water.ca.gov/swp/milestones.cfm> (17 November 2003).

2 California Department of Water Resources, "Management of the California State Water Project," *Bulletin 132-92* (Sacramento: California Department of Water Resources, Dec. 1992) 14-15 and 150-151. Dan Flory, Chief of State Water Project Analysis Office, personal interview, 20 August 2003.

3 Dan Flory, personal interview, 20 August 2003.

4 Josh Newcom and Elizabeth McCarthy, *Layperson's Guide to Water Marketing.* (Sacramento: Water Education Foundation, 2000), 17.

5 James Beck, Assistant General Manager, and Gary Bucher, Water Resources Manager, Kern County Water Agency, personal interview, 29 August 2003.

6 Robert Gottlieb and Margaret Fitzsimmons, *Thirst for Growth: water agencies as hidden government in California* (Tucson: University of Arizona Press, 1991), 94.

7 James Beck and Gary Bucher, personal interview, 29 August 2003.

8 For background information on the Monterey Amendments, see the California Water Network's white paper "The Monterey Agreement—The State Water Project Contracts (SWP)—The Kern Fan Element" (March 2003) and Tim Stroshane, "Monterey Agreement: A Bloodless Coup" *Spillway: California Water, Land and People* 1, no. 2 (2000).

9 This requirement was stated in Article 18(b) of the State Water Project contracts. The Monterey Amendments eliminated Article 18(b) from the contracts. See *Hatch and Parent Law Offices* "Monterey Amendments and White Paper" (September 1995) p.10.

10 *Planning and Conservation League v. Department of Water Resources* (15 September 2000) 83 Cal. App. 4th 892, 912-913 (hereinafter PCL v. DWR).

11 *PCL v. DWR.* Also, see California Water Network's white paper "The Creation of 'Paper Water' & State Water Reliability" (March 2003).

12 Norris Hundley, Jr. *The Great Thirst: Californians and Water: A History* (Berkeley: University of California Press, 2001), 525.

13 PCL v. DWR.

14 The Settlement Agreement may be accessed online at: California Department of Water Resources, *Monterey Agreement Overview,* <http://www.montereyamendments.water.ca.gov> (17 November 2003).

15 *Settlement Agreement by and among Planning and Conservation League, Plumas County Flood Control and Water Conservation District, Citizens Planning Association of Santa Barbara County, Inc. and The State of California Department of Water Resources, Central Coast Water Authority, Kern Water Bank Authority, and those State Water Project Contractors identified herein.* (5 May 2003) 22. Available at <http://www.montereyamendments.water.ca.gov/> (17 November 2003).

16 Carolee Krieger, President of the California Water Network, personal interview, 9 June 2003.

17 Tim Stroshane, "Monterey."

18 Jonathan Parker, General Manager, and Cheryl Harding, Administrator, Kern Water Bank Authority, personal interview, 11 June 2003.

19 Kern Water Bank Authority, "Project Description," (Bakersfield: Kern Water Bank Authority, undated) 2.

20 Michael Gardner, "Imperial-federal dispute could torpedo water deal," *San Diego Union Tribune,* 12 September 2003.

21 Kern Water Bank Authority, "Project Description," 2

22 Jonathan Parker and Cheryl Harding, personal interview, 11 June 2003.

23 Legislative Counsel, State of California "Official California Legislative Information" <http://www.leginfo.ca.gov>. On Assembly Bill 2014 see: <http://www.leginfo.ca.gov/cgi-bin/postquery?bill_number=ab_2014&sess=9394&house=B&author=assembly_member_cortese> (17 November 2003).

24 Jonathan Parker and Cheryl Harding, personal interview, 11 June 2003.

25 *Ibid.*

26 *Ibid.*

27 Ray Sotero, "Davis names key leaders for his ag-water team." *California Farm Bureau Federation* 2 December 1998 <http://www.cfbf.com/agalert/1996-00/1998/aa-1202c.htm> (17 November 2003).

28 The staff eventually conceded that Paramount was "associated with Westside."

29 Jonathan Parker and Cheryl Harding, personal interview, 11 June 2003.

30 *Ibid.*

31 *Ibid.*

32 The receptionist at Roll International responded to a telephone request to speak with their public information specialist by saying that they do not give information to the public. When

asked who would be the best person to contact with research questions she responded: "I suggest you don't research us" and hung up. The call took place on 1 July 2003.

33 Ellen D. Wernick, "Roll International Corporation" in Tina Grant, Ed. *International directory of company histories Vol.* 37 (Farmington Hills: St. James Press, 2001), 337.

34 Sunkist, "Sunkist Growers Elect New Board" 6 February 2002. <http://www.sunkist.com/press/releases/2002-0206.asp> (17 November 2003).

35 Wernick, *International directory*, 337-338.

36 Sotero, "Davis names," (17 November 2003). See also: Wernick, *International directory*, 338.

37 Delaware Corporations LLC, "Why Delaware? & FAQ," <http://www.delawarecorp.com/faqs.htm> (17 November 2003).

38 Joseph N. DiStefano, "In Delaware, Enron found secrecy and savings," *Philadelphia Inquirer*, 31 January 2002.

39 Keith Dovkants, "The 'vultures' threatening the Diana fund," *This is London: from the Evening Standard*, 25 November 2002. <http://www.thisislondon.com/news/articles/2191439?source=Evening%20Standard> (17 November 2003). The Resnicks also own a home, a lodge, and rental property in Aspen, Colorado where they sued Pitkin County over an affordable housing project that the county planned to build near their property. See, Troy Hooper, "Charity squeeze in London linked to Aspen," *Aspen Daily News*, 13 July 2003 <http://www.aspendailynews.com/Search_Articles/view_article.cfm?OrderNumber=6079> (17 November 2003).

40 Information on awards from the following websites: UCLA Today, <http://www.today.ucla.edu/html/020625 commencement.html> (17 November 2003); Entertainment Today,<http://www.ent-today.com/3-26/hollywood-beat.htm> (17 November 2003); Getty House Foundation, <http://www.gettyhouse.org/CityofAngels.htm> (17 November 2003).

41 California Automated Lobbying and Campaign Contribution & Expenditure Search System *Cal Access*, <http://cal-access.ss.ca.gov/> (17 November 2003). Search results for "Stewart Resnick," or Filer ID: 499047.

42 Sotero, "Davis names," (17 November 2003).

43 Paramount Farms, *Paramount Farms Incorporated*, 2003 <http://www.paramountfarms.com> (17 November 2003).

44 Video on <http://www.paramountfarms.com>. Paramount Farming Company owns around 120,000 acres in Kings and Kern counties. See: Dan Bryant, "Paramount Farming taps pomegranate market surge," *Western Farm Press*, 2 August 2003. <http://westernfarmpress.com/ar/farming_paramount_farming_taps/> (17 November 2003).

45 California Farm Bureau Federation, *CFBF.com*, "Facts and Stats About California Agriculture," 2002 <http://www.cfbf.com/info/agfacts.aspx> (17 November 2003) and "Food and Farm News," 28 January 2003 <http://www.cfbf.com/ffn/2003/ffn-01_28_03.html> (17 November 2003).

46 *Ibid.* and Foreign Agricultural Service, Horticultural and Tropical Products Division "The U.S. Almond Industry: Situation and Outlook," June 2001 <http://www.fas.usda.gov/htp/horticulture/Tree%20Nuts/almonds.pdf> (17 November 2003) 2.

47 Harry Cline, "Pistachios may hit 144 million pounds" *Western Farm Press* 6 September 2003 <http://westernfarmpress.com/ar/farming_pistachios_may_hit/index.htm> (17 November 2003).

48 Dan Bryant, "Paramount Farming taps pomegranate market surge," *Western Farm Press*, 03 July 2003 <http://westernfarmpress.com/ar/farming_paramount_farming_taps/> (17 November 2003) and Kern County Agricultural Commissioner, *Annual Crop Report*, 1980-1987 <http://www.co.kern.ca.us/kernag/crp_idx.htm> (17 November 2003).

49 Gottleib and Fitzsimmons, *Thirst for Growth*, 101.

50 Wernick, *International directory*, 338.

51 Western Farm Press, "Paramount buys most Dole citrus," 21 October 2000 <http://westernfarmpress.com/ar/farming_paramount_buys_dole/index.htm> (17 November 2003) and Wernick, *International directory*, 338.

52 On drops in CA Ag: Steven C. Blank, "Is this California agriculture's last century?" *California Agriculture*, July-August 2000. On Paramount's acreage increase: See Paramount's Kern County pesticide permits 1994-2003 online at <http://www.co.kern.ca.us/kernag/crp_idx.htm> (17 November 2003).

53 Figures from the U.S. Department of Agriculture, *1997 Census of Agriculture* cited in Blank, "Is this California," 23.

54 Dennis Pollock, "Ag loses ground in state" *Fresno Bee*, 5 June 2003. <http://www.fresnobee.com/business/story/6899634p-7835870c.html> (17 November 2003).

55 See the video on Paramount Farms available online at: <http://www.paramountfarms.com> (17 November 2003).

56 Parker, Harding and Scott Hamilton, Resource Planning Manages, Paramount Farming Company, personal interviews, June and July 2003.

57 Vic Pollard, "Kern Water Bank will likely stay with county," *Bakersfield Californian*, 27 January 2003 <http://www.bakersfield.com/local/story/2530749p-2583014c.html> (17 November 2003).

58 Nossaman Gunther Knox & Elliot, "Land Use, Environment, Real Property & Water: Representative Work" <http://www.nossaman.com/practice/areas_recentwork.asp?groupid=6&areaid=6> (17 November 2003).

59 *Ibid.* Italics added.

60 City of Bakersfield, Economic and Community Development Department, <http://www.ci.bakersfield.ca.us/edcd/> (17 November 2003).

61 Scott Hamilton, personal interview, 2 July 2003.

62 *Ibid.*

63 Dan Bryant, "California almonds seek offshore sales," *Western Farm Press*, 14 May 2001 <http://westernfarmpress.com/ar/farming_california_almonds_seek_2/index.htm> (17 November 2003).

64 Vic Pollard, "Los Angeles eyeing Kern water source" *Bakersfield Californian* 24 March 2002

65 *Ibid.*

66 *Ibid.*

67 "Agreement for the Reservation of Water." Dated 12 March 2001. Signed by John MacIlvaine for WV Acquisition Corp. and Steven D. Zimmer for Newhall Land and Farming Company. On file at Public Citizen.

68 Richard Fausset, "Supervisors OK Newhall Ranch," *Los Angeles Times*, 28 May 2003 and Richard Fausset, "Newhall Project Gets OK to Build," *Los Angeles Times*, 28 October 2003.

69 PCL v. DWR

70 Patti Shea, "Agency to Search Newhall Ranch," *The Signal*, 1 June 2002.

71 *Friends of the Santa Clara River v. Castaic Lake Water* Agency S104550, Supreme Court of California, 2002 Cal. and Castaic Lake Water Agency, *Castaic Lake Water Agency 16,000 AF Transfer and Annexations—Initial Study*, 18 July 2003.

72 Water Association of Kern County, *Who's Who in Kern County Water*, <http://www.wakc.com/whoswho.htm> (17 November 2003).

73 Lynne Plambeck, personal interview, 10 June 2003.

74 *Ibid.*

75 *Ibid.*

76 Dale Kasler, "Kern county a hub of the water trade" *Sacramento Bee* 14 July 2002 <http://www.sacbee.com/content/news/projects/liquid_assets/story/3572159p-4600478c.html> (17 November 2003).

77 Kasler, "Kern county," 14 July 2002.

78 Tom Glover, Deputy Director of DWR, personal interview, 11 August 2003 and Michael Jackson, water attorney, personal interview, 9 August 2003.

79 Michael Jackson, personal interview, 9 August 2003.

80 Kasler, "Kern county," 14 July 2002.

81 Ellen Hanak, *Who Should Be Allowed to Sell Water in California? Third-Party Issues and the Water* (San Francisco: Market Public Policy Institute of California, 2003), 15.

82 Tim Stroshane, "Rural Counties connect dots for Environmental Water Caucus," *Spillway News*, (Summer 2002), 2.

83 Josh Newcom, "Is the California Water Market Open for Business," *Western Water*, (March/April 2001), 12.

84 See Mike Taugher, "Water proposal pumps it south," *Contra Costa Times*, 7 August 2003 <http://www.bayarea.com/mld/cctimes/living/science/6478006.htm> (17 November 2003). On participants in the meetings: Tom Glover, Deputy Director of California Department of Water Resources, personal interview, 11 August 2003; Jeff McCracken, U.S. Bureau of Reclamation, personal interview, 8 August 2003; Dan Nelson, San Luis Delta Water Authority, personal interview, 16 September 2003; John Coburn, State Water Contractors, personal interview, 16 September 2003 .

85 Michael Machado, "Letter to the Editor: Water plans need results," *San Joaquin Record*, 27 August 2003.

86 Available online at: <http://www.leginfo.ca.gov/.const/.article_10> (17 November 2003).

87 Joseph Sax, "The Public Trust Doctrine in Natural Resource Law: Effective Judicial Intervention," *Michigan Law Review* 68 (January 1970): 484.

88 Kenneth W. Umbach, "A Statistical Tour of California's Great Central Valley" *California Research* Bureau August 1997. Online at: http:www.library.ca.gov/CRB/97/09/#Heading1 (last accessed 17 November 2003). For information and stunning visual images on the Central Valley and the impacts of water diversion projects discussed in this report, see Jon Else's PBS Documentary *Cadillac Desert. Program 3: The Mercy of Nature.*

89 Hundley, *Great Thirst*, 9, also fn.11, 568.

90 Hundley, *Great Thirst*, 239 and Devin Galloway and Francis S. Riley "San Joaquin Valley, California: Largest human alteration of the Earth's surface" in Devin Galloway *et. al.* eds. *Land Subsidence in the United States* U.S. Geological Survey Circular 1182 available online at: <http://water.usgs.gov/pubs/circ/circ1182/pdf/06SanJoaquinValley.pdf> (17 November 2003) and CALFED Bay Delta Program *Final Programmatic EIS/EIR* (Sacramento: CALFED Bay Delta Program, July 2000) 5.4-12.

91 Hundley, *Great Thirst*, 257-258.

92 Hundley, *Great Thirst*, 241.

[93] Hundley, *Great Thirst*, 276.

[94] See the interview with Pat Brown in: Malca Chall. *California Water Issues, 1950-1966*. (Berkeley: Bancroft Library Oral History Program, 1981). Marc Reisner wrote: "'Lie' is a strong word, but in this case it is advised, because one day Pat Brown would all but admit it himself." See: Marc Reisner. *Cadillac Desert: The American West and Its Disappearing Water* Revised and Updated. (New York: Penguin Books, 1993) 351.

[95] California Department of Water Resources, "Management of the California State Water Project," *Bulletin 132-01* (Sacramento: California Department of Water Resources, 2001) and State of California Resources Agency, *The California State Water Project*, Undated.

[96] Department of Water Resources, *Bulletin 132-01*, Ch. 14.

[97] Hundley, *Great Thirst*, 280.

[98] Department of Water Resources, *Bulletin 132-01*, 12.

[99] Gottleib and Fitzsimmons, *Thirst for* Growth, 93.

[100] Hundley, *Great Thirst*, 297.

[101] California Department of Water Resources, "California Water Plan Update," *Bulletin 160-98* (Sacramento: California Department of Water Resources, 1998) Ch. 3.

[102] Reisner, *Cadillac Desert*, 334.

[103] Hundley, *Great Thirst*, 295-297.

[104] Villarejo, *New Lands*, 2.

[105] Hundley, *Great Thirst*, 297.

[106] Department of Water Resources, *Bulletin 132-01*, p.12

[107] See Gottlieb and Fitzsimmons, *Thirst for* Growth.

[108] Hundley, *Great Thirst*, 536.

[109] Gottlieb and Fitzsimmons, *Thirst for* Growth, 94.

[110] *Ibid*, 94.

[111] *Ibid*, 96-97.

[112] Kern County Water Agency, *Annual Report 2000*, 10.

[113] Gottlieb and Fitzsimmons, *Thirst for* Growth, 5.

[114] Hundley, *Great Thirst*, 290.

[115] Gottlieb and Fitzsimmons, *Thirst for* Growth, 16.

[116] *Ibid*, 97.

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Attachment 6

# An Environmental Review of CalSim-II:

## Defining "Full Environmental Compliance" and "Environmentally Preferred" Formulations of the CalSim-II Model


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November 2005

Table of Contents

Preface ..... 3
Executive Summary ..... 5
Context ..... **Error! Bookmark not defined.**
Background and Motivation ..... 11
Scope of the Review Process ..... 13
Water Year Indices and the Role of Foresight in CalSim-II Risk Tolerance ..... 14
D1485 Indices ..... 15
D1485 Water Year Type Index: ..... 15
D1485 Snowmelt Index: ..... 15
D1485 2-year Index ..... 15
D1485 Fish & Wildlife Standards Index ..... 15
D1485 Project Deficiency Index ..... 16
DWR Indices ..... 16
40-30-30 Sacramento Basin Index ..... 16
60-20-20 San Joaquin Basin Index ..... 16
CVP Indices ..... 16
Shasta Index (CVP) ..... 17
American River D893 Index ..... 17
Miscellaneous Indices ..... 17
The Trinity River Index ..... 17
Eight River Index ..... 17
The Influence of Water Year Indices on the Definition of Risk Tolerance ..... 17
Detailed Analysis of Specific Environmental Regulations ..... 22
Trinity Operations ..... 29
Shasta/Keswick Downstream Releases ..... 32
Oroville/Thermalito Downstream Releases ..... 36
Folsom/Nimbus Downstream Releases ..... 38
New Melones/Goodwin Downstream Releases ..... 43
Delta Outflow Requirements ..... 48
Full Environmental Compliance CalSim-II Formulation Work Plan ..... 53
Removing Perfect Foresight from the Definition of Environmental Regulations ..... 53
Revising the (B)(2) Accounting Logic ..... 55
Activity 2: Implement conditional logic to govern the implementation of the final revised (b)(2) CalSim-II step. ..... 58
Including Minimum Instream Flows for the San Joaquin River Below Friant ..... 58
Activity 1: Define a release schedule ..... 58
Activity 2: Implement the Friant Release Logic ..... 59
Activity 3: Perform Sensitivity Analysis on the two Release Regimes ..... 59
Environmentally Preferred CalSim-II Formulation Work Plan ..... 60
Adapting the Representation of Existing Regulations ..... 60
Allowing for Evaluation of Alternative Flow Regimes ..... 63
Conclusions ..... 65

## Preface

The "Environmental Review of CalSim-II" was undertaken at the request and under the sponsorship of Water For California, a non-profit organization dedicated to sound stewardship of the State's waters. The original work statement given to the Natural Heritage Institute requested that they examine the CalSim-II code to establish the requirements to meet two specific standards: one, to determine what changes in the data inputs and the code would be necessary to capture "full compliance" with the legal mandates under which the State Water Project (SWP) and the Central Valley Project (CVP) operate; and the second, to establish in a similar fashion the changes in data and code which would be required to perform an "an environmentally preferred" analysis.

> This report is prompted by the use of CalSim-II by agencies as the preferred tool for environmental impact analysis, even though the model is constructed as an optimization model for maximizing exports given certain hydrology and constraints. This report raises a number of important questions and issues with regard to the way CalSim-II is being used.

The "full compliance" option was deemed necessary because present operations of the projects are not fully implementing measures sufficient to meet legal and regulatory requirements promulgated to protect and restore important fisheries and habitats. These deficiencies include directives of the State Water Resources Control Board, the CVPIA's Anadromous Fishery Restoration Programs (AFRP), and more. Each affects operational requirements on dam and pumping operations to protect fisheries and Delta water quality standards. It is important for the investigation to determine just how the code treats these legal directives on the operations of projects and to determine how the CalSim-II model could be used to investigate the impact on project operations if these directives were followed.

The "restoration planning" option was held to be necessary because it was plainly apparent that existing operations, even with expected stricter adherence to the spirit of the environmental limitations, were not effective in redressing the damage that has been incurred to the environment over the lives of these projects. Simply put, the projects, including the present format of CALFED, do not appear adequate to restore health to the Delta and the fisheries as was intended by these programs and as directed by the Endangered Species Act. Again the investigation was required to determine what additional requirements and changes might be added to CalSim-II to move us in the direction of environmental restoration.

> We anticipate that implementation of the proposed changes to CalSim-II will elevate environmental objectives to the same level afforded consumptive water uses in water resource decision-making.

This report is prompted by the use of CalSim-II by agencies as the preferred tool for environmental impact analysis, even though the model is constructed as an optimization model for maximizing exports given certain hydrology and constraints. It raises a number of important questions and issues with regard to the way CalSim-II is being used. We anticipate that implementation of the proposed changes to CalSim-II will elevate environmental objectives to the same level afforded consumptive water uses in water resource decision-making.

Water for California
November, 2005

## Executive Summary

CalSim-II is being used in almost every significant water planning process underway in California. When the outcome of a planning process hinges on modeling results, even partially, the assumptions and assertions that lead to these results should be accurate and transparent. Unfortunately, the 2003 peer review of CalSim-II raised a number of concerns about the applicability of the model to these important planning processes. The report published here, *An Environmental Review of CalSim-II*, was prepared in order to improve the transparency of CalSim-II and to measure the current version of the model against two important standards. This report is purposely focused on and limited to two specific questions.

1. **Does the representation of environmental regulations and objectives in CalSim-II represent full compliance with current legal requirements?**
2. **Can CalSim-II be used to plan for water management alternatives associated with improve environmental outcomes and habitat restoration?**

This report does not deal with any of the other CalSim-II issues identified in the CalSim-II Peer Review. The Natural Heritage Institute (NHI) was engage to carry our technical analysis needed to answer these questions.

*Full Compliance*

The first question is posed in order to assure that the current formulation of CalSim-II is consistent with all current environmental regulations on California's water resources. CalSim-II attempts to characterize all components of the regulatory structure. This report reviewed a significant but limited subset of these regulations. Those reviewed were selected based on the experience of a panel of environmental experts. This selection does not imply that characterizations of other regulation in CalSim-II meet the full compliance standard. In fact, it would be very valuable to complete a similar analysis on the model characterization of all environmental regulations.

**Results** With regards to the Full Compliance standard, NHI identified three areas where the assumptions and assertions in the current version of CalSim-II were at odds with the expert panel's interpretations of existing environmental regulations:

- **CalSim-II uses information not available to real time operators of the California water system.** This allows CalSim-II to relax environmental standards earlier than is the case in actual operations. As a result, the model under-allocates water needed to satisfy existing environmental regulations; in turn, the model makes that water available for export to south of Delta contractors or other uses.
- **CalSim-II is not faithful to Federal law that allocates water to meet ecosystem restoration objectives.** The 1992 Central Valley Project Improvement Act calls for 800 TAF of water to be allocated for environmental regulation and the logic of CalSim-II does not fully honor this requirement.
- **CalSim-II currently includes no requirement to maintain a minimum flow in the San Joaquin River below Friant Dam**, contrary to a court ruling requiring such flows. This allows for allocation of water to urban and agricultural uses in the Friant Service area rather than allocating that water to maintain water in the San Joaquin River.

For each of these deficiencies, this report proposes a series of actions that can be taken in order to improve the performance of the model. These should be considered the minimum steps required to meet the Full Compliance standard for the regulations reviewed as part of this effort.

*Restoration Planning*

The second question is motivated the failure to protect and restore the Sacramento-San Joaquin watershed as legally required. Long-term monitoring of the system suggests that threatened and endangered fish populations are in serious jeopardy. A prudent approach to water management planning would use modeling tools that evaluate the impact of various environmental regulations on water deliveries. CalSim-II has not been crafted to include this flexibility.

**Results** As examples of the kinds of new regulations that may need to be considered in CalSim-II, the expert panel identified the following regulatory changes that the model should be able to accommodate:

- CalSim-II should have the flexibility to shift salinity compliance points to allow more targeted tributary restoration action. For example, changing the location of the Vernalis salinity standard may reduce the burden on the Stanislaus River.
- CalSim-II should have the capacity to shift required salinity profiles in the Delta (X2) to benefit Delta-dependent species.
- CalSim-II should allow for the prioritization of tributary environmental objectives, such as targeted operation of the Nimbus/Folsom system for the American River.
- CalSim-II should allow for the modification of Delta export restrictions to target improvements in the Delta ecosystem.
- CalSim-II should not count, towards the satisfaction of environmental regulations, water that otherwise would have been releases as part of unavoidable reservoir spills.
- CalSim-II should allow for the definition of flow requirements that result in periods of spring high-flow and summer low-flow conditions in Central Valley rivers.

These changes are consistent with the need to comply with existing environmental laws (CEQA, NEPA, ESA) through the evaluation of alternatives, including those that are the most environmental beneficial. Given the historic difficulty associated with return the Central Valley water system to a viable ecosystem, these changes would allow policy makers to engage in more thoughtful restoration planning. This report includes a workplan to implement these changes. The responses to the proposed actions should be considered markers of the long-term utility of CalSim-II for restoration planning.

*Conclusion*

Having completed this environmental review of the CalSim-II model, we are left with the profound impression that it is not a tool that can – under its current formulation – fully address the legally required water management objectives. CalSim-II is, after all, a tool that has been designed to determine how best to operate the state's hydraulic infrastructure in ways that maximize the satisfaction of contractual demands. This reality is a result of both the history of water model development in California and a general analytical approach that has held sway for decades in the field of water resources planning and analysis. This approach holds that the environment is a constraint on system operations, not one of the objectives for which the system should be managed. In order to create a tool that can investigate water management innovations designed to comply with the law and restore the environment, it is not simply a matter of adjusting a few input parameters. Instead, a reformulation of the model along the lines described in this document is needed.

CalSim-II holds that the environment is a constraint on system operations, not one of the objectives for which the system should be managed. In order to create a tool that can investigate water management innovations designed to comply with the law and restore the environment, it is not simply a matter of adjusting a few input parameters.

This philosophy of including the environment as an objective in water resources management is gaining credence around the world. Unfortunately, in California we cannot get to this point if we limit ourselves to the current version of CalSim-II. On the positive side, it is clear that no one views the current version of CalSim-II as the final and definitive water planning tool. An effort is underway to develop CalSim-III, which will respond to many of the critiques that have been offered about the model in recent months and years.

The conclusions of this report are offered to constructively contribute to this evolution. We feel that they will elevate, when implemented, aquatic ecosystem restoration to a place alongside of the other water management objectives in the system as is consistent with the imperatives of law and policy. A failure to respond to these critiques would demonstrate, on the other hand, that the water management community has little interest in viewing ecosystem restoration as more that a nettlesome constraint that has to be dealt with, preferably in the most minimal fashion. This would represent a division more profound than some varying professional opinions about the best way to model a complex water resource system.

## Approximating Natural Systems in Models

When modeling a natural system, especially a complex one like the Delta and the water systems that support life in it, it is important to consider the context for the modeling effort. This section of the report briefly describes some of the systems and processes impacted by water management decisions. The overall goal of this section is to highlight the need for modelers to understand the natural systems they attempt to represent and for stakeholders to understand the rationale behind assumptions used to represent environmental regulations within water management model logic.

The plants, fish, birds, and other animals that are native to California streams, rivers and wetlands evolved to flourish under the particular climatic and hydrologic patterns of their native watersheds. Prior to development, streams routinely flooded outside of their embankments during strong winter storms and heavy periods of spring snowmelt runoff. By late summer streams ran low and in drought years many sections of smaller rivers and streams dried up completely. In the fall, the first rains would refresh streams and rivers and attract anadromous fish like the fall run Chinook salmon to migrate back up into the watershed to spawning grounds in mid-elevation reaches. Dried-up floodplains and wetlands would begin to fill again in time for the migrating waterfowls to find refreshed habitat.

The riparian forest along California's streams also adapted to these conditions and contributed to the character of the ecosystems in California's rivers and streams. Being inundated throughout much of the winter and spring does not harm the willow, alder, cottonwood and other riparian plants, and the shallow waters around their trunks are important habitat for juvenile fish escaping the faster moving waters in the main currents. In addition, the riparian forest provided much of the food for the aquatic life around them as terrestrial bugs dropped into the waters below.

The seasonal pulses of flow down California's rivers and streams into the Delta interacted with the daily and seasonal tidal fluctuations in the San Francisco Bay to create a shifting pattern of freshwater, brackish water and salt water that was shaped by the complex and shifting flow patterns in the Delta itself to form a mosaic of aquatic habitats. This mosaic supported a complex assemblage of Delta resident plants and animals.

> Californians value their native aquatic ecosystems. A system of environmental laws and regulations, including minimum flow requirements and restrictions on water diversions, has been developed in reaction to serious damage to ecosystems including declines and even loss of species and degradation and loss of habitat.

It goes without saying that conditions changed with the onset of water development in California. The building of levees isolated rivers from their floodplains and fragmented the mosaic of ecosystems in the Delta. The construction and operation of dams and diversion works for water extraction changed the natural flow regimes in ways which reduced the amount of flooding and increased the level of flows in managed rivers and streams during the low

flow period. In the Delta, the combined influence of channelization and changes in the flow regime vastly reduced the amount of certain habitat types used by Delta resident species. These changes were counter to the evolutionary tendencies of native plants and animals throughout the system and were often favorable to invasive species.

This synopsis of pre-development California aquatic ecology and the changes that accompanied water development is not intended to serve as a utopian alternative to the highly developed water system that has been constructed in California over the past century. Indeed, the vast majority of Californians, to one degree or another, rely upon the hydraulic manipulations that water development has accomplished. By the same token, Californians value their native aquatic ecosystems. A system of environmental laws and regulations, including minimum flow requirements and restrictions on water diversions, has been developed in reaction to serious damage to ecosystems including declines and even loss of species and the degradation and loss of habitat. This is the environmental regulatory structure that the developers of CalSim-II have attempted to capture in a simulation model of the California water system.

So just what is CalSim-II and how did it come to play such a central role in California water planning? In order to answer these questions a little bit of historical context is required. For several decades, the managers of the Central Valley Project and the State Water Project have used computer models to simulate the operations of their particular projects. The original models, which went by the names of ProSim for the CVP facilities north of the Delta, SanJaSim for the CVP facilities in the San Joaquin Valley, and DWRSim for the SWP facilities, where used to simulate the extent to which facilities could be operated to meet contractual water demands given a set of assumptions regarding legal requirement and the operating environment. They assumed that historic hydrologic conditions were a decent representation of the likely future. The models were not integrated and therefore it was difficult to evaluate the constraints and opportunities imposed by simultaneous operations of the projects. In addition, the models themselves were developed over many years in a somewhat ad hoc manner with new model logic being added over time as new operating and regulatory approaches were articulated. The end result was a set of codes that were complex, relatively unstable, and nearly impossible to navigate and support as many of the original developers had retired or moved on.

By the 1990s this was clearly an untenable situation on several counts. First, the Delta was in crisis. Ecosystem functions were negatively impacted, and salmon and other species were listed under the ESA. Delta water diversions and extraction over a period of decades was understood to be at least a part of the reason for the problems. The Coordinated Operating Agreement between the CVP and the SWP, and the CALFED Bay-Delta Program, called for closer coordination of CVP and SWP operations to respond to the problem and to legal mandates to restore the populations of listed species. Second, the stakeholder community was demanding a more flexible and transparent set of analytical tools at the very time when the pool of competent ProSim, SanJaSim, and DWRSim analysts was dwindling. Finally, advances in the field of water resources analysis and planning were providing more flexible approaches to water resource simulation modeling based on the application of user-defined priorities and preferences rather than the rigid, If-Then rules used in developing the original models. The time was

right to construct a new simulation model of the California water system, and the managers of both the CVP and the SWP committed resources in an effort to accomplish this task.

At this point, a few observations are warranted. While CalSim-II represents an improvement over the original simulation models in terms of its integration of the State's hydraulic infrastructure, it is clearly derivative from those earlier models. Much of the data and logic used in the original models was introduced to CalSim-II. As a result, CalSim-II still seeks to simulate the extent to which facilities could be operated to meet contractual water demands given a set of assumptions regarding the operating and regulatory environment, and assuming that the range of historic hydrologic conditions is representative of future conditions. As in the early codes, the logic of CalSim-II is designed to maximize the degree to which infrastructure can be operated to satisfy contractual demands. In addition, while CalSim-II is more flexible and stable than the earlier codes, it is not transparent to those outside of the relatively small CalSim-II modeling community.

As a result of this situation, significant questions regarding the model's suitability for multi-objective water resource planning have been raised at the very same time that CalSim-II analyses are being used to inform numerous planning and decision-making processes. There exists a nagging suspicion that the model is not amenable to a full consideration of environmental restoration objectives, and there is a real frustration that it is nearly impossible to address this doubt by examining the logic and assumptions contained in CalSim-II.

> This report seeks to evaluate the degree to which CalSim-II captures the critical characteristics of the existing regulatory structure and explore how the model could be used to evaluate the implications of environmental management strategies that more closely mimic the natural hydrologic conditions under which native aquatic plants and animals in California evolved.

This report reviews a subset of CalSim-II logic dealing with environmental regulation and seeks to evaluate the degree to which this subset of the model captures the critical characteristics of the existing regulatory structure. A similar analysis should be completed on the entire model by the official CalSim-II development team. This report also explores how the model could be used to evaluate the implications of environmental management strategies that more closely mimic the natural hydrologic conditions under which native aquatic plants and animals in California evolved. The first goal is to assure that CalSim-II correctly models existing environmental regulations. A second goal is to create a model that can be used to explore objectives that go beyond maximizing deliveries to meet contractual demands and which instead seek to balance the restoration of California's aquatic environment with the demands for urban and agricultural water use.

## Background on CalSim II

CalSim-II was developed collaboratively by the California Department of Water Resources and the United States Bureau of Reclamation. It is the primary water supply planning tool employed by the managers that extract water from the Central Valley water system. CalSim-II is being used to support numerous studies (e.g. the Integrated Storage Investigation) and environmental processes (e.g. the Monterey EIR), requiring that the model's logic, structure and limitations and their influence on the conclusions drawn from model output be both understood and accepted as valid by stakeholders involved in these efforts.

Developing a model that can be accepted as credible, relevant, and useful by those with an interest in the model results is a central challenge in the use of all water resource planning models. For the CalSim-II model, this challenge is magnified by the overall complexity of the Central Valley water system, and the scale at which operations need to be represented. An important response to this challenge occurred in 2003 when a panel of nationally recognized experts conducted a peer review of the CalSim-II model and published a strategic review of how the model could appropriately support water planning, management, and operations in California[1].

> The peer review did not specifically address the manner in which CalSim-II represents the environmental regulations and objectives established for the Central Valley water system.

The peer review, which was managed by the CALFED Bay-Delta Program and published by the Association of Bay Area Governments, produced many important critiques of the overall CalSim-II approach. These included, among others:

- Its extreme reliance on the output of other models as CalSim-II model input without adequate consideration of the assumptions implicit in these other models;
- Its rudimentary representation of important groundwater resources in the system; and,
- Its failure to undergo a classic calibration and validation analysis prior to its deployment in numerous water resources decision-making processes.

The peer review did not specifically address, however, the manner in which CalSim-II represents the environmental regulations and objectives established for the Central Valley water system.

This report describes an effort specifically designed to consider the issue of environmental performance and compliance with environmental requirements. In implementing this review, which involved detailed examination of CalSim-II code and model output, two questions were posed:

[1] Close, A., W.M. Hanemann, J.W. Labadie. D.P. Loucks (chair), J.R. Lund, D.C. McKinney, and J.R. Stedinger. 2003. **A Strategic Review of CALSIM II and its Use for Water Planning, Management, and Operations in Central California**. Association of Bay Area Governments. Oakland, California.

1. Does the representation of environmental regulations and objectives in CalSim-II represent full compliance with current legal requirements?
2. Can CalSim-II be used to plan for water management alternatives associated with improve environmental outcomes and habitat restoration?

In formulating a response to these questions, the effort specifically sought to define a series of actions that could be taken to make CalSim-II responsive to these "full environmental compliance" and "environmentally preferred" standards. For this assessment, compliance was defined as representing all current and pertinent environmental laws and regulations in a manner consistent with how they are actually implemented. Environmentally preferred includes environmental restoration measures that might emerge from on-going regulatory processes, different interpretations of existing regulations, or measures that go beyond current regulatory requirements but are appropriate for long-term planning studies. In particular, we are interested in how CalSim-II could be used to evaluate management strategies that contribute to the restoration of aquatic ecosystems and not the perpetuation of the declining situation under the status quo.

This environmental review was funded by Water for California and managed by the Natural Heritage Institute. Owing to its in-house technical capacity using CalSim-II, NHI was responsible for identifying and describing environmentally pertinent details of the CalSim-II model, including details of both the CalSim-II model logic and results from the Common Assumptions Baseline model runs. Through a series of meetings and one-on-one interactions, NHI collaborated with analysts from Wolf and Associates, the Bay Institute, and Environmental Defense to evaluate and measure these details against the full environmental compliance and environmentally preferred standards. NHI then used the results of this collaboration to formulate two distinct work plans that would (i) assure full environmental compliance and (ii) reflect desired and/or anticipated regulatory changes with regard to environmental services in the Central Valley system. The motivation for this effort is that the implementation of these work plans will increase the level of acceptance afforded the CalSim-II model by the environmental stakeholder community. Absent this acceptance, the usefulness of CalSim-II in multi-stakeholder planning and environmental review processes may be unnecessarily compromised.

## Scope of the Review Process

In defining the scope of the CalSim-II environmental review, several general observations about the model proved instructive:

- The CalSim-II model treats environmental considerations as constraints on system operations rather than as objectives to be included in the water allocation optimization routine.
- While some environmental constraints are defined for a particular river/reservoir system, others, in particular the accounting logic associated with implementation of section 3406(b)(2) of the Central Valley Project Improvement Act, have system-wide implications.
- There are numerous local and system-wide sets of environmental constraints in CalSim-II, including regulations for 12 Central Valley rivers and creeks, in the Sacramento-San Joaquin Delta and associated with (b)(2) accounting.

The first observation is important because while treating environmental objectives as "constraints" assures that they will be satisfied, it also requires that certain *a priori* assumptions be made in defining the constraints. Some of these assumptions currently apply perfect foresight through the use of water year indices. This foresight influences the manner in which risk tolerance is captured in the CalSim-II water allocation logic that does not correspond with actual operational decisions made in pursuit of environmental objectives.

The second observation has implications because the approach taken in integrating different local regulations into a governing system-wide constraint set can be as important as the definition of the local constraints themselves. For example, the model logic that applies local environmental operations against (b)(2) obligations can be as important as the logic governing the definition of a minimum flow for a particular river reach.

The third observation this report reviewed a significant but limited subset of these regulations. Those reviewed were selected based on the experience of a panel of environmental experts. This selection does not imply that characterizations of other regulation in CalSim-II meet the full compliance standard.

The flow of this document turns first towards the role that water year indices play in the characterization of environmental constraints and objectives, with specific reference to the definition of risk tolerance in CalSim-II. The report then examines a set of specific environmental regulations in greater detail, examining the model logic that governs the establishment of environmental constraints on the CalSim-II water allocation logic. The report closes with detailed workplans designed to move CalSim-II towards full environmental compliance and environmentally preferred standards that were applied during this model review. While much technical detail has been included in the discussion of water year indices and specific environmental regulations, an honest attempt was made to limit the technical detail to those items that have a direct bearing on the proposed work plans. We ask for our reader's patience in working through the technical details and promise that the effort will be rewarded through a fuller capacity to evaluate the proposed workplans found in the final section of the report.

## Water Year Indices and the Role of Foresight in CalSim-II Risk Tolerance

CalSim-II considers environmental objectives to be constraints on the water allocation optimization routine. While the current treatment of environmental regulations assures that environmental "constraints" are satisfied before any water is allocated to other purposes, *the model decides whether or not environmental flows are to be met in full* ***in advance*** *of all other allocations.* This reduces the many environmental unknowns and creates more manageable resource allocation problems but it also serves to optimize water exports rather than environmental outcomes.

This approach is inconsistent with the manner in which water resource allocations actually evolve between the months of February and May, when inflows are highly uncertain. Further, the formulation of environmental objectives as constraints removes the possibility that the environmental objectives for the system will benefit from the same level of optimization as other beneficial uses and hides the need to consider the real environmental impacts of water management activity, namely the condition of the ecosystem.

The formulation of environmental objectives as constraints removes the possibility that the environmental objectives for the system will benefit from the same level of optimization as other beneficial uses and hides the need to consider the real environmental impacts of water management activity, namely the condition of the ecosystem.

This approach to modeling environmental compliance is problematic in terms of responding to the two questions posed in this model review. These criteria focus on the actions necessary to restore California's aquatic ecosystems in order to comply with environmental law rather than simply meeting delivery targets. It also calls into question the use of CalSim-II as a tool for environmental impact assessment, since it is changes in the environment associated with specific projects and not the satisfaction of arbitrary constraints which is the critical focus of environmental review.

Discerning the contours of this problem involves understanding the source and environmental application of all the water year indices used in CalSim-II. Before examining specific indices, it is worth pointing out that water year indices are read into CalSim-II from look-up tables, and they are invariant for a 12-month period subsequent to the month in which they are updated. The index values themselves are pre-calculated from the historic 1921-1994 data used as input to the model. In other words, water year types are defined with *perfect foresight*. Text Box 1 presents a summary of indices that govern environmental standards in CalSim-II.

The following text describes these indices in greater detail and highlights the ways in which they are used to establish environmental constraints. This text is followed by a description of how these indices influence environmental constraints in the CalSim-II water allocation routine and, thereby, how this impacts the final service throughout the system vis-à-vis the risk tolerance logic applied to non-environmental deliveries. Prior to continuing, however, it is important to point out that this document's focus indices use, rather than on the scientific justification of the indices themselves, is not to be interpreted

as an acceptance of the actual indices. The use of data from the previous year has an inappropriate impact on the values of the individual indices.

### *D1485 Indices*

Five water year indices defined by D1485 standards are used to determine Delta Outflow requirements, as they would have been executed under Decision 1485. In addition, they are used for accounting purposes in assigning 'costs' to the (b)(2) account. Each of the indices is updated during the February time step and remains invariant for the subsequent 12 months.

**Text Box 1: Water Year Indices Used to Define Environmental Constraints**

- D1485
  - D1485 Index
  - D1485 Subnormal Snowmelt Index
  - D1485 2-year Index
  - D1485 Fish and Wildlife Standards Index
  - D1485 Project Deficiency Index
- DWR Indices
  - 40-30-30 Sacramento Basin Index
  - 60-20-20 San Joaquin Basin Index
  - Feather River Basin Index
- CVP Indices
  - Shasta Index
  - American River D893 Index
- Miscellaneous
  - Trinity River Index
  - 8-River Index

#### D1485 WATER YEAR TYPE INDEX:

The D1485 index[2] has 5 levels: 1 = Wet, 2 = Above Normal, 3 = Below Normal, 4 = Dry, 5 = Critically Dry. The index is used in the calculation of the 1485 Fish and Wildlife Index.

#### D1485 SNOWMELT INDEX:

The D1485 Snowmelt index[3] has 2 levels: 1 = Above Normal, 2 = Sub-Normal. The index is used in defining Minimum Required Delta Outflow (MRDO) requirements under the D1485 regulatory simulation.

#### D1485 2-YEAR INDEX

The D1485 2-year index[4] has 2 levels: 0 = normal D1485 conditions, 1 = post-Critical Water Year conditions. Analysis of the input data reveals that the post-Critical Water Year conditions do not always follow years with a D1485 index value of 5, or Critically Dry. The index is used in the calculation of the D1485 Fish and Wildlife Index.

#### D1485 FISH & WILDLIFE STANDARDS INDEX

The D1485 Fish & Wildlife Standards Index is based on the current values of the D1485 Index and the D1485 2-year Index. Essentially, when the D1485 2-year Index is 1, post-Critical Water Year conditions, the value of the D1485 Index is increased by one increment corresponding to the next drier condition. The D1485 Fish and Wildlife Index

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[3] ...\D1485\Run\Lookup\wytypeSnow.table
[4] ...\D1485\Run\Lookup\wytype2yr.table

is then used to define the Rio Vista minimum flow requirement[5]. Additionally, this index is used to define Minimum Required Delta Outflow (MRDO) requirements under the D1485 regulatory simulation.

#### D1485 Project Deficiency Index

The D1485 Project Deficiency Index[6] has 2 levels: 0 = no deficiencies, 1 = deficiencies. This index is used in defining Minimum Required Delta Outflow (MRDO) requirements under D1485 flow requirements.

### *DWR Indices*

Two DWR indices, which are defined in February and remain invariant for the subsequent 12 months, are used for setting minimum flow standards for certain rivers as well as Delta outflow standards.

#### 40-30-30 Sacramento Basin Index

The 40-30-30 Sacramento Basin Index[7] has 5 levels: 1 = Wet, 2 = Above Normal, 3 = Below Normal, 4 = Dry, 5 = Critically Dry. The index is used in i.) defining the volume of water in the (b)(2) account, ii.) determining reservations of (b)(2) water to assure that (b)(2) is not entirely depleted in the fall, iii.) changing the salinity standards in the Delta, iv.) changing the Minimum Required Delta Outflow[8], and v.) defining the Rio Vista minimum flow requirement[9].

#### 60-20-20 San Joaquin Basin Index

The 60-20-20 San Joaquin Basin Index[10] has 5 levels: 1 = Wet, 2 = Above Normal, 3 = Below Normal, 4 = Dry, 5 = Critically Dry. The index is used to define minimum flow requirements in certain river reaches. Flow requirements affected by the index include the minimum flows on the Calaveras and Mokelumne River, the San Joaquin ERPP (Ecosystem Restoration Program Plan) flows (May 1-10), as well as the VAMP (April 15 – May 15) and Vernalis (October) requirements, which can be relaxed when conditions are dry.

### *CVP Indices*

The Shasta and American River CVP indices included in CalSim-II are used to determine minimum flow requirements in the Sacramento basin. Values of the CVP indices are updated in March and remain invariant over the subsequent 12 months.

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[7] ...\Run\Lookup\wytypes.table
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[9] ...\common\Delta\Riovista\riovista.wresl
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SHASTA INDEX (CVP)

The Shasta Index[11] has 4 levels, where a value of 4 is considered Critically Dry. The Shasta index is used to determine minimum flows in Clear Creek and at Red Bluff. When the index equals 4, reductions are made to Refuge Contracts North of the Delta[12].

AMERICAN RIVER D893 INDEX

The American River D893 Index[13] has 2 levels and is used to determine the H Street minimum flow requirements, specified in Decision 893. Requirements at H Street vary by month and are specified in a lookup table[14].

### *Miscellaneous Indices*

Several stand-alone indices that are applied at various places in the system are also used to set environmental constraints.

THE TRINITY RIVER INDEX

The Trinity River Index[15] has 5 levels: 1 = Wet, 2 = Above Normal, 3 = Below Normal, 4 = Dry, 5 = Critically Dry. The Trinity Index is set in April and held constant throughout the year. The Trinity River Index is used to determine minimum flow requirements in the Trinity River. Requirements for the Trinity River vary by both month and are specified in a lookup table[16].

EIGHT RIVER INDEX

The Eight River Index[17] is a table of pre-calculated, invariant numbers derived from analysis of historic data. The Eight River Index is used to define Minimum Required Delta Outflow requirements in January.

The most fundamental observation that can be made based on the information presented in the preceding section is that some environmental standards are set based on perfect foresight about the values assigned to water year indices. This assumption can influence the operational logic of the model. Understanding how this operational logic ignores the risk of operating for dynamic environmental objectives is critical to the application of the full environmental compliance and environmentally preferred standards to the performance of CalSim-II.

### *The Influence of Water Year Indices on the Definition of Risk Tolerance*

The most fundamental observation that can be made based on the information presented in the preceding section is that some environmental standards are set based on perfect

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foresight about the values assigned to water year indices. This assumption can influence the operational logic of the model. Understanding how this operational logic ignores the risk of operating for dynamic environmental objectives is critical to the application of the full environmental compliance and environmentally preferred standards to the performance of CalSim-II. The easiest way to explain how risk management for the environment could be improved is to illustrate how CalSim-II approaches risk management in promising water deliveries.

CalSim-II relies upon a series of curves to manage uncertainty in promising water to users throughout California: generally these curves define risk tolerance. Specifically, these curves illustrate the ability to promise water deliveries given a specific water year outlook (not to be confused with the water year indices). While the treatment of risk tolerance varies somewhat between the CVP and SWP systems, the procedure used in the CVP portion of the model is illustrative. CVP water allocations (i.e. monthly varying delivery promises) are set by the Water Supply Index-Demand Index (WSI-DI) curve, Figure 1. Here the promised CVP delivery (embedded in the Demand Index) is determined by the specific water year outlook (determined by the Water Supply Index). Unlike the water year indices, the water supply index (WSI) is calculated every month as the sum of storages *plus* an imperfect forecast of inflows.

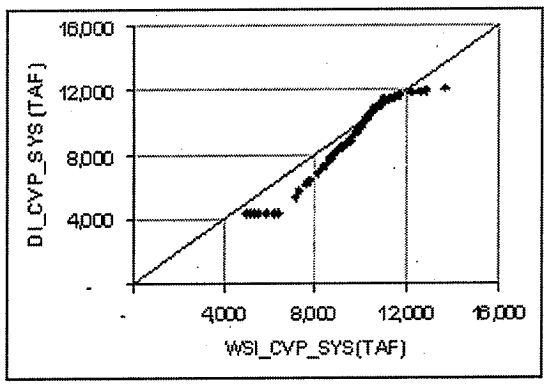


**Figure 1 – WSI-DI Curve for CVP water allocations**

Three interesting observations emerge from Figure 1. First, at very high levels of water supply the corresponding demand flattens out. This is associated with the fact that the system demand is not unlimited and that above a certain water supply threshold, all water demand can be satisfied. Second, at very low water supply values, the demand index is also flat. This corresponds to the hard water demand that will exist even in the driest conditions. Finally, intermediate to these two tails, an increase in water supply translates into an increase in the water demand that can be satisfied. At high water supply levels all of the available supply is allocated to meet demand. As the water supply decreases, however, the WSI-DI curve falls below the 1:1 line suggesting that a smaller percentage of the available supply is made available to meet demand. This is the first part of the CalSim-II's risk tolerance definition: when conditions are dry, caution is taken in promising water to meet demand.

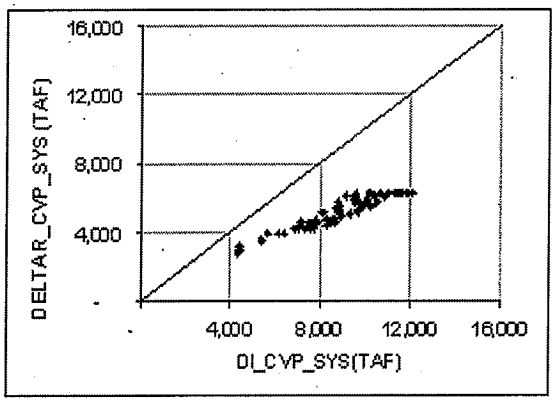


**Figure 2 – Del-Car Curve for CVP water allocations**

The Demand Index, however, is the sum of both delivery and carry-over storage demands. A second step in determining the CVP water allocations in CalSim-II involves partitioning of the available water between CVP contractors and storage in CVP reservoirs. The Delivery-Carry Over (DelCar) Curve, Figure 2, accomplishes this. Note that the curve has a high-end tail similar to the WSI-DI curve, which occurs during full contract deliveries to CVP contractors. As the Demand Index decreases in value, a smaller percentage of the available supply is committed to carry over storage relative to the amount that is delivered to meet current water demand. This is the second component of the risk tolerance included in CalSim-II: as conditions get dry, a larger percentage of available supply is used to meet current demands in the hope that future inflows will restore reservoir storage levels. Notice that at a DI value of roughly 4000 TAF, the nearly all of the water available to meet demand, is being delivered to satisfy current needs.

At this point the reader is probably wondering how the shape of these two curves are established. In other words, how is the acceptable level of risk tolerance defined? The answer is that some trial and error takes place to train the WSI-DI and DelCar curves. Before describing this process, however, a short digression is made to respond to the other question likely on the mind of the reader, namely how are forecasts of reservoir inflows used to define WSI?

CalSim-II makes a series of annual water allocation decisions starting in February of each water year. At that moment, based on an analysis of historic conditions that has been conducted outside of CalSim-II, knowledge of the snow pack above the major reservoirs in a given water year is added to the level of precipitation that, over the ensuing 5 months, has been exceeded 99% of the time in the historic record. A simple regression model developed by the Department of Water Resources is then used to translate the existing snow pack and anticipated rainfall into a predicted level of reservoir inflow that is added to the water already in reservoir storage to yield the Water Supply Index shown on the x-axis of Figure 1. Unless there is an unusually large snow pack in place in February, by anticipating such a low level of precipitation, CalSim-II likely forces the value of WSI to fall relatively low on the x-axis of Figure 1. This translates to a relatively modest commitment to satisfy demand that may results in delivery cuts being set by the allocation logic relative to full contract amounts.

The forecasted reservoir inflow is updated during the March, April and May time-steps using the process described above and historic information on the available snow pack and future precipitation at the levels exceeded 90, 75 and 50% of the time, respectively. These updated reservoir inflow forecasts are combined with the simulated level of reservoir storage to define a new value of WSI that is translated to a commitment to deliver water to satisfy current needs. If this leads to a higher level of delivery, then the cut logic invoked during an earlier time step is relaxed. By June, the value of WSI is considered fixed for the current water year.

One final comment is warranted. If the situation worsens as the process is implemented, for example if warm late winter temperatures deplete the snow-pack, forcing releases from reservoirs to comply with flood control obligations, and the actual precipitation is less than that which was forecast, the allocation logic will not reduce the quantity of deliveries defined during a previous time step, and end-of-year carry-over storage will be reduced as a consequence.

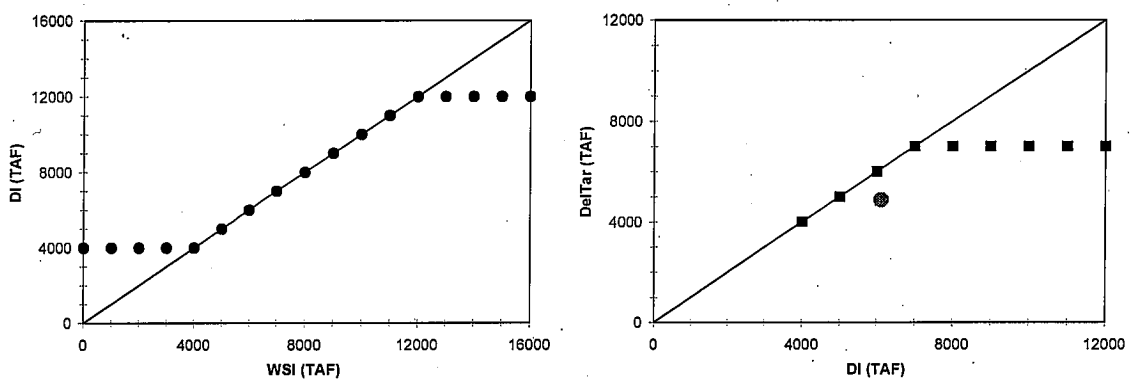


**Figure 3 – Stylized Representation of Maximum Risk Tolerance**

As alluded to above, the WSI values arrived at by implementing this iterative process drive the use of the WSI-DI and DelCar Curves shown in Figures 1 and 2. This brings us back to the question of how the shape of the curves is established. The most aggressive possible operational strategy for providing water to users would be to use all of the available supply to meet current needs. This posture is stylized in Figure 3. As in Figures 1 and 2, the tails at the upper and lower values of WSI and DI have been preserved. At intermediate values, however, all available water is used to satisfy the current need for water deliveries as both the WSI-DI and DelCar Curves follow the 1:1 line. This posture, however, presumes that the system is completely unconstrained in its ability to deliver all available water to demands throughout the Central Valley. Four primary constraints act to prevent this aggressive delivery policy.

1. There is uncertainly associated with the forecast value of WSI;
2. The actual physical capacity of installed infrastructure can limit water deliveries;
3. Carry-over storage is critical to meeting water management objectives in future years; and most importantly from the perspective of this review
4. Constraints related to environmental regulations may limit the delivery of water.

These factors could, therefore, conspire to create a situation whereby the actual deliveries to demands throughout the system would be somewhat less than promised (e.g. the circle on the right-hand graph in Figure 3). This failure to deliver promised water is in essence a "broken promise" to contractors, and was deemed unacceptable to the CalSim-II development team. To avoid this situation, the WSI-DI and DelCar Curves were developed to add prudence to the interpretation of how much water is available, and what fraction thereof is deliverable. Obviously, this is a departure from the most aggressive posture (Figure 3) toward the aversion to promise deliveries that ultimately cannot be made as expressed in Figure 1 and Figure 2.

The most fundamental observation from the review of CalSim-II is that the environmental constraints used to train the WSI-DI and DelCar Curves were based on a number of *a priori* assumptions, including perfect foresight associated with the use of water year indices. Our thoughts on the implications of the assumptions are found in the section discussing proposed work plans to meet the Full Compliance and Environmentally Preferred standards. The overall implications of perfect foresight should also be kept in mind as the reader reviews the details of specific environmental standards found in the following section.

## Detailed Analysis of Specific Environmental Regulations

As mentioned earlier, CalSim-II includes representations of numerous environmental standards, more in fact than could be examined given the time and resources available to this review process. Starting from the input matrix that is typically used to describe a CalSim-II model formulation, the following table identifies the portions of CalSim-II Common Assumptions Baseline code that we evaluated as part of this study.

| Regulatory Standards |
|---|
| Trinity River |
| Upper Sacramento River |
| Feather River |
| American River |
| Stanislaus River |
| Sacramento-San Joaquin Delta |
| **Operations Criteria** |
| Subsystem |
| • Stanislaus River |
| System Wide |
| • CVP Water Allocation |
| • CVPIA 3406(b)(2) |

Before launching into the specific details of particular environmental regulations, it is probably worthwhile to present the logic of model cycles and model steps used in CalSim-II. CalSim-II is, in fact, run iteratively (recall the discussion of cycles) with different assumptions being applied to the model during each iteration. The pattern of iteration is shown in Figure 4.

Beginning in October, the first month of a water year, CalSim-II executes a series of model cycles that iteratively add objectives to the system. The first cycle involves meeting delivery requirements on the east side of the San Joaquin Valley. During the second cycle, base operations are checked against certain water quality standards for the San Joaquin River, and additional releases are made if required and possible. In the third cycle, it attempts to satisfy pulse flow requirements for the San Joaquin River and its tributaries. The fourth cycle checks that the San Joaquin River water quality standards are still being met after the addition of the pulse flows, and it makes adjustments if needed and feasible. The fifth and final cycle for the San Joaquin River applies specific objectives such as the Vernalis Adaptive Management Plan and the Stanislaus River dissolved oxygen standards.

At the end of the fifth cycle, the CalSim-II representation of San Joaquin River inflows to the Delta is established for the month. The next two cycles add in all of the model logic related to the water management in the Sacramento River, the Delta and the Export zone. Once releases under all seven cycles are calculated, CalSim-II moves on to the next month of the water year. The set of seven calculation cycles continues until calculations for the final month of the water year, September, are completed.

At this point, it is important to introduce and define a new term: "steps." Steps represent the final, monthly set of releases for a 12 month water year. CalSim-II utilizes several

steps before finalizing monthly releases made throughout each water year. Each step in CalSim-II corresponds with a particular water resource policy benchmark. CalSim-II is required to calculate releases under multiple policy regimes because policies (such as the (b)(2)) manage and account for water deliveries relative to releases that *might* have been made under prior regulatory environments.

The first CalSim-II step, referred to as D-1485, calculates releases that would have been made under the regulatory environment pre-dating the enactment of the Water Quality Control Plan. Older regulatory environments can present opportunities to deliver water that are greater than they would be under present conditions. These 'false' opportunities are not reported as the actual availability of water, but are instead used to measure changes in delivery as a result of changes in regulatory policy.

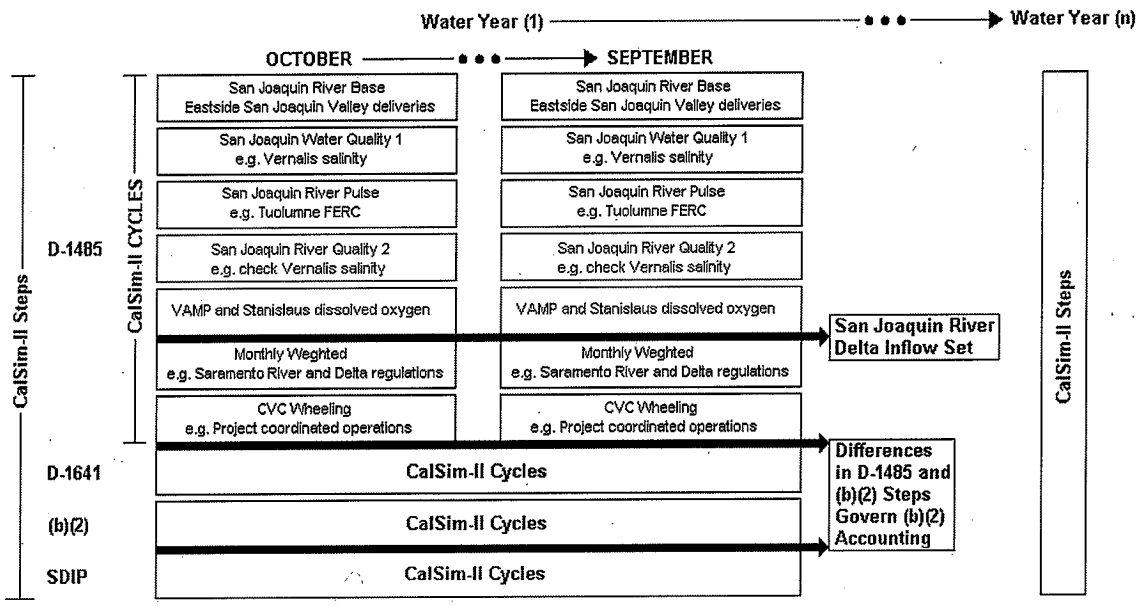


**Figure 4 – CalSim-II model cycles and steps**

The second CalSim-II model step assumes that the Water Quality Control Plan is in place, which increasingly constrains the ability to deliver water. Any reduction is accounted for as the cost of implementing the Water Quality Control Plan. The next model step assumes that the (b)(2) provisions of the CVPIA require between 600 and 800 TAF of CVP water to be rededicated to environmental objectives. During this step, in completing the seven cycles for the 12 months of a water year, CalSim-II invokes a series of actions that can provide the extra water relative to that which was used for environmental purposes in the D-1485 step. This implies that additional environmental water uses associated with implementation of the Water Quality Control Plan are counted against the (b)(2) obligation. Once all of the environmental considerations are addressed, CalSim-II completes a final step to resolve management considerations related to the adoption of the South Delta Improvement Plan. Only after all cycles and steps are completed for a given 12 month water year does CalSim-II move on to calculations for the following water year, beginning with October.

The implications of this pattern of iteration employed by CalSim-II should be kept in mind as the reader reviews details of specific environmental regulations presented below.

### *CVPIA 3406(b)(2) Accounting*

Section 3406(b)(2) of the Central Valley Project Improvement Act states that the Central Valley Project will:

> "dedicate and manage annually 800,000 acre-feet of Central Valley Project yield for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by this title; to assist the State of California in its efforts to protect the waters of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; and to help to meet such obligations as may be legally imposed upon the Central Valley Project under State or Federal law following the date of enactment of this title, including but not limited to additional obligations under the Federal Endangered Species Act."

This prescription has, since the passage of CVPIA, been the focus of protracted legal and administrative wrangling. The key questions relate to whether or not the 800 TAF dedication to restoration efforts applies in all years and what actions taken in the operation of the CVP system can be considered as acceptable contributions to the (b)(2) account. In May 2003 the Department of the Interior issued what are considered to be the current rules for interpreting Congressional intent. These are summarized below.

A. Accounting Period

The accounting period for determining the use of the annual (b)(2) allocation will be October 1 through September 30.

B. Accounting Methodology

The appropriate accounting methodology for the dedication and management of (b)(2) water is based upon how and where the water is used. Interior's new methodology for accounting for (b)(2) will involve only two measurement methods, or metrics, to account for how the water is managed under (b)(2). The two metrics used will be upstream releases and Delta exports.

1. Upstream Actions – October 1 through September 30

   a. Accounting Methodology

   Upstream fishery actions from October 1 through September 30 will be accounted as the increase in releases from upstream reservoirs with the fishery actions, compared to releases from the reservoirs[18] that would have resulted from baseline CVP operations[19] during the same period without the fishery actions. The calculation of the increase in release with the fishery measures will be based on daily changes in releases resulting from the (b)(2) measures prescribed by the Fish & Wildlife Service (Service), accumulated over the period.

   b. Upstream Releases may Flow through Delta

   If specified by Interior, based on a written assessment of biological benefits to the fishery from the Service, steps will be pursued under California law to allow upstream releases to flow through the Delta. Upstream releases specified to flow through the Delta would be accounted for solely under this provision, and not as Delta actions.

2. Delta Actions that affect Exports – October 1 through September 30

---

[18] Releases from Trinity Reservoir for Trinity River flows pursuant to 3406(b)(23) of the CVPIA are excluded from the accounting under this provision. Releases to the river from Whiskeytown Dam, Keswick Dam, Nimbus Dam and Goodwin Dam comprise the basis for this metric.

[19] Interior is currently using the pre-1992 base CVP operations with D-1485 water quality obligations as the baseline CVP operation. The pre-1992 baseline includes the 1992 Winter Run Chinook Salmon Biological Opinion and other licenses and permits as construed at that time.

a. Accounting Methodology

Delta actions that affect exports will be accounted throughout the water year as the reduction in exports from the Delta resulting from the prescribed fishery actions. Any export reductions prescribed by the Service below the baseline operation will be accounted as (b)(2) actions. The calculation of decrease in Delta exports with the fishery measures will be based on daily changes in Delta exports with the fishery measures will be based on daily changes in Delta exports resulting from the (b)(2) measures prescribed by the Service, accumulated over the period.

b. Limitation on Delta Actions – February 1 through August 31

During the period February 1 through August 31 (the "low point" for CVP storage in San Luis Reservoir), (b)(2) prescriptions for export reductions will be limited to a maximum of 640,000 acre-feet (80 percent of 800,000 acre-feet of (b)(2) water). This maximum amount will be reduced up-to 80 percent when the overall water available to (b)(2) is reduced in Dry and Critical water years.

The Department of the Interior decision continues to state, "... for the purposes of classifying the water year type and developing operation plans, the 90-percent exceedence hydrology will be used."

Translating these legislative and administrative guidelines into CalSim-II model logic is a complicated endeavor. Two observations regarding the manner in which this was accomplished are particularly relevant to this environmental review. First, in spite of the suggestion that some notion of uncertainty be applied to the determination of water year type, CalSim-II employs perfect foresight in determining the amount of water that must be dedicated to (b)(2) actions. Based on the 40-30-30 Sacramento River Index which is read into CalSim-II during the February time step, CalSim-II sets the size of the (b)(2) account for the entire water year at the levels shown in Table 1.

CalSim-II employs perfect foresight in determining the amount of water that must be dedicated to (b)(2) actions.

**Table 1 – Annual (b)(2) requirements based on Sacramento River water year type**

| Sacramento River Water Year Type | (b)(2) Requirement (TAF) |
|---|---|
| Wet | 800 |
| Above Normal | 800 |
| Normal | 800 |
| Below Normal | 700 |
| Critically Dry | 600 |

The second pertinent observation is that CalSim-II employs the simulated operation of the system following the D-1485 step (see Figure 4, above) as a baseline against which additional ecosystem restoration actions called for under (b)(2) are measured. This implies that all CVP actions related to implementation of the D-1641 Water Quality Control Plan are considered to be acceptable charges against the (b)(2) account. This belies the fact that water quality actions can have little direct ecosystem benefit. These

observations will be taken up again the discussion of the full environmental compliance and environmentally preferred work plans. For the moment, the remainder of this sections deals with actions taken during the CalSim-II (b)(2) step in order to satisfy (b)(2) obligations.

This implies that all CVP actions related to implementation of the D-1641 Water Quality Control Plan are considered to be acceptable charges against the (b)(2) account. This belies the fact that water quality actions can have little direct ecosystem benefit.

As stated in the Department of the Interior guideline, either increases in releases from CVP regulating reservoirs (Whiskeytown, Keswick, Nimbus, and Goodwin), or decreases in CVP Delta exports relative to a pre-1992 baseline, can be considered to constitute contributions against the (b)(2) obligations. These are described in the standing interpretations, and in CalSim-II, as the Release Metric and the Export Metric. In operation, both are calculated daily. In CalSim-II, the release metric is calculated as the **increase** in total end-of-month releases from CVP reservoirs finalized in the (b)(2) step, relative to the simulated end-of-month releases from CVP reservoirs in the D-1485 step. In the event that the (b)(2) step reduces outflows from CVP reservoirs (relative to D-1485), the (b)(2) account is not credited.

Similarly, the Release Metric is defined as the reduction in end-of-month CVP Delta exports for the (b)(2) step, relative to the D-1485 step. Increased exports (relative to D-1485) are not credited to the (b)(2) account, and the total possible charge to the Release Metric is limited to a fraction of the (b)(2) account. Generally, one of three actions results in a charge to the Release Metric. 1) Changes to the Delta salinity standards between the (b)(2) and D-1485 steps could result in a reduction to exports, 2) exports could be curtailed in the months in April and May as part of the Vernalis Adaptive Management Plan (VAMP), or 3) exports could be curtailed in June in order to bring the (b)(2) account into compliance with the target ecosystem budget.

**Table 2 - April and May VAMP export cuts for (b)(2)**

| Flow at Vernalis (cfs) | CVP Delta Export Restrictions | | |
|---|---|---|---|
| | April 1 – 14 | April 15 – May 15 | May 16 – 31 |
| < 5700 | 17.5% Inflow | 750 CFS | 3000 CFS |
| 5700 – 8600 | 17.5% Inflow | Alternate 750 CFS and 1500 CFS | 3000 CFS |
| > 8600 | 17.5% Inflow | 25% Flow at Vernalis | 3000 CFS |

VAMP export restrictions from April 1 to May 31 are always activated for (b)(2) accounting purposes (Table 2). The (b)(2) export restrictions apply to CVP Delta exports from Tracy and Banks. During the first non-pulse period, April 1-14, total Delta exports from Tracy and Banks are limited to 35% of Delta inflow[20], with the CVP and the SWP

[20] The sum of Sacramento River flows at Hood, Yolo Bypass return flows, San Joaquin River flows at Vernalis, Mokelumne River, Calaveras River, and Marsh Creek inflows to the Delta.

each being apportioned 50% of the water. During the April 15 – May 15 pulse period, CVP Delta exports are restricted to 750 cfs if the VAMP requirement is less than 5700 cfs. If the VAMP requirement is greater than 5700 cfs then CVP delta exports are restricted to either 750 or 1500 cfs, depending upon the previous year's VAMP restriction. This export restriction alternates between years. Maximum CVP exports are increased to 25% of flows at Vernalis if they are greater than 8600 cfs. In the second non-pulse period, May 16-30, CVP Delta exports are restricted to 3000 cfs. If extending the pulse period restrictions through the end of May is more than what is needed to satisfy (b)(2) requirements then the pumping restrictions for May 16-31 will be adjusted to a level that brings the CVP into compliance with its (b)(2) obligations.

CVP delta exports in June are always restricted to a maximum of 3000 cfs. If there are remaining (b)(2) costs that are not met by projected WQCP actions then CVP pumping at Tracy and Banks will be curtailed. June CVP delta pumping can be reduced from the 3000 cfs standard, but cannot be reduced below the level of export pumping simulated during May. In addition, pulse period pumping restrictions can be applied for the first 7 days in June and increased to 3000 cfs for the remaining 23 days of the month. If extending the pulse period restriction through the first week of June exceeds the amount needed to satisfy (b)(2) requirements then June pumping restrictions will be adjusted to a level that brings the CVP into compliance with its (b)(2) obligations.

Keep in mind as you read the following sections and work plans that modeling (b)(2) correctly requires both correct representation and correct comparison. Representation is more or less an issue of capturing the regulated policy, e.g. there are 800 TAF for disbursement. Comparison is an issue of appropriately capturing the accounting baseline, and charging specific accounts at the appropriate point within the myriad of cycles and steps being performed to calculate operations.

A comment: CalSim-II contains an impressive bulk of code devoted specifically to the accounting of (b)(2) water. Literally, over half of the current model could be eliminated if the (b)(2) account were not being tracked. This demonstrates the power and flexibility of CalSim-II's environment for adopting incremental accounting regulations such as (b)(2). Conversely, this makes an enormous statement about the magnitude of effort required to track "packets" of water running through the Central Valley, as if water releases were so many parcels being ferried through a factory on conveyor belts. While tracking incremental quantities may be appropriate for contracted deliveries, it is an ill-conceived starting point for protecting environmental services because they depend more upon the 'state' of the system than upon raw quantities. There is a need to move away from incremental policies such as the (b)(2) toward dynamic water management decision making that is driven by targeted responses to current environmental conditions. This suggestion also speaks directly to a primary issue that stakeholders have with models: transparency. Quite simply, less complex accounting procedures require less code. Less code makes water resource

There is a need to move away from incremental policies such as the (b)(2) toward dynamic water management decision making that is driven by targeted responses to current environmental conditions.

models simpler to explain, to track and to understand: thereby making the dialogue over alternatives more accessible to stakeholders. While the authors harbor no great illusions about California's water resource system and regulatory environment getting simplified, we suggest it as a practical rule of thumb for future policy directions.

## Trinity Operations

CalSim-II models releases of water from storage in the Trinity System along two arcs, marked in Figure 5 as C100 (Trinity River) and D100 (Clear Creek Tunnel). The logic dividing flows between the Trinity River releases and diversion towards the Sacramento River are relatively straightforward.

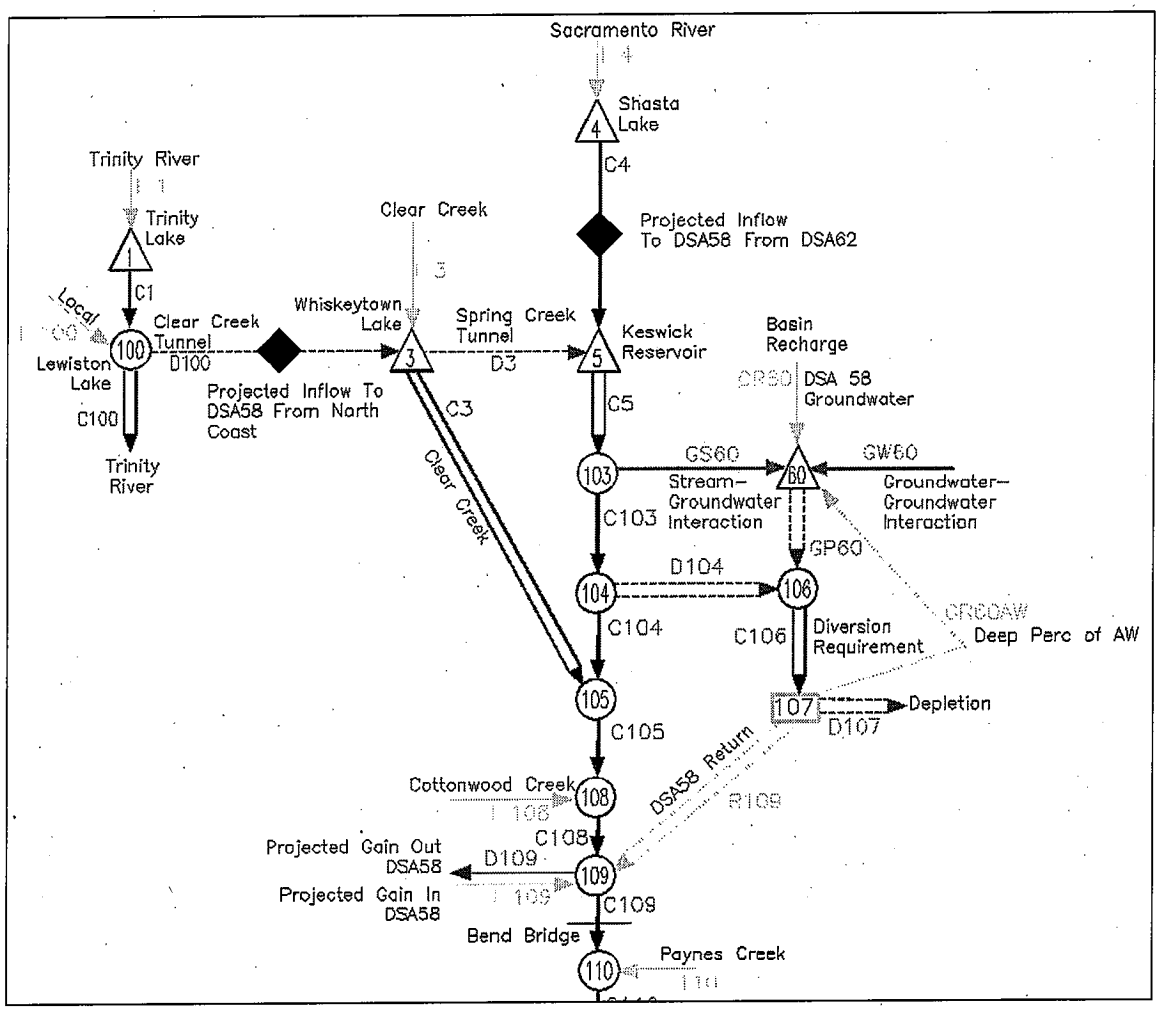


**Figure 5 - Trinity Storage and Releases, represented on the CalSim-II schematic as reservoir 1 and arcs C100 (Trinity River) and D100 (Clear Creek Tunnel)**

The Trinity River water year index determines the release schedule for the Trinity River[21]. The release schedule is referenced from a lookup table (Table 3), and is the same for each CalSim-II step.[22] Notice that there are significant differences between required releases to the Lower Trinity depending on the water year index, particularly during the late spring and early summer months. This is the kind of difference that has implications for the manner in which risk tolerance is established in CalSim-II, as discussed in the previous section.

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**Table 3 – Trinity River minimum flow requirements (cfs), set by the Trinity water year index**

| Month | Trinity River Water Year Index | | | | |
|---|---|---|---|---|---|
| | Wet (1) | Above Normal (2) | Below Normal (3) | Dry (4) | Critical (5) |
| October | 373 | 373 | 373 | 373 | 373 |
| November | 300 | 300 | 300 | 300 | 300 |
| December | 300 | 300 | 300 | 300 | 300 |
| January | 300 | 300 | 300 | 300 | 300 |
| February | 300 | 300 | 300 | 300 | 300 |
| March | 300 | 300 | 300 | 300 | 300 |
| April | 427 | 460 | 493 | 540 | 600 |
| May | 4570 | 4709 | 4189 | 2924 | 1498 |
| June | 4626 | 2526 | 2120 | 783 | 783 |
| July | 1102 | 1102 | 1102 | 450 | 450 |
| August | 450 | 450 | 450 | 450 | 450 |
| September | 450 | 450 | 450 | 450 | 450 |

Trinity river transfers to the Sacramento River basin are made through the 3300 cfs Spring Creek tunnel into Whiskeytown Reservoir. The transfer goal is set relative to the storage levels in Lake Shasta and in reservoirs on the Trinity River. In both cases, Storage Level 1 corresponds to the lowest storage zone, in which case a reservoir is extremely drawn down. At the highest reservoir storage levels, Level 5 for the Trinity reservoirs and Level 6 at Lake Shasta, reservoirs are so full that they are spilling water. Table 2 shows the assigned relationship between the Trinity to Sacramento transfer targets and the storage levels in the two reservoirs.[23] These transfer values can be exceeded when, for instance, Trinity is spilling and the "excess flows" in the Trinity River are used to augment CVP storages or to meet Delta outflow objectives. This is important because when the Trinity River transfers are increased between the D1485 step and the (b)(2) step, the transfer of this "excess flow" is accounted for as a charge against the (b)(2) obligations. As a result the model may be able to avoid clearly beneficial environmental actions called for under (b)(2) during the spring months.

This is important because when the Trinity River transfers are increased between the D1485 step and the (b)(2) step, the transfer of this "excess flow" is accounted for as a charge against the (b)(2) obligations. As a result the model may be able to avoid clearly beneficial environmental actions called for under (b)(2) during the spring months.

[23] ...\Run\Lookup\trinity_import.table

**Table 4 – Trinity River Diversions through Clear Creek Tunnel (cfs)**

| Trinity Level | Shasta Level | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 250 | 250 | 250 | 250 |
| 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 250 | 250 | 250 | 250 |
| 1 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 250 | 250 | 250 | 250 |
| 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 250 | 250 | 250 | 250 |
| 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 250 | 250 | 250 | 250 |
| 1 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | |
| 2 | 1 | 250 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 250 | 1500 | 1500 | 1000 |
| 2 | 2 | 250 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 250 | 1500 | 1500 | 1000 |
| 2 | 3 | 250 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 250 | 1250 | 1250 | 1000 |
| 2 | 4 | 250 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 250 | 1000 | 1000 | 750 |
| 2 | 5 | 250 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 250 | 750 | 750 | 500 |
| 2 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | |
| 3 | 1 | 1250 | 750 | 250 | 250 | 250 | 250 | 250 | 250 | 1250 | 2500 | 2500 | 1750 |
| 3 | 2 | 1250 | 750 | 250 | 250 | 250 | 250 | 250 | 250 | 1250 | 2500 | 2500 | 1750 |
| 3 | 3 | 1000 | 500 | 250 | 250 | 250 | 250 | 250 | 250 | 1000 | 2250 | 2250 | 1500 |
| 3 | 4 | 750 | 500 | 250 | 250 | 250 | 250 | 250 | 250 | 750 | 1750 | 1750 | 1500 |
| 3 | 5 | 750 | 250 | 100 | 100 | 100 | 100 | 100 | 100 | 750 | 1500 | 1500 | 1000 |
| 3 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | |
| 4 | 1 | 1750 | 1000 | 250 | 250 | 250 | 250 | 250 | 250 | 1750 | 3250 | 3250 | 3250 |
| 4 | 2 | 1750 | 1000 | 250 | 250 | 250 | 250 | 250 | 250 | 1750 | 3250 | 3250 | 3250 |
| 4 | 3 | 1500 | 750 | 250 | 250 | 250 | 250 | 250 | 250 | 1500 | 2500 | 2500 | 2500 |
| 4 | 4 | 1250 | 500 | 250 | 250 | 250 | 250 | 250 | 250 | 1250 | 2000 | 2000 | 2000 |
| 4 | 5 | 750 | 500 | 100 | 100 | 100 | 100 | 100 | 100 | 750 | 1500 | 1500 | 1500 |
| 4 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | | | |
| 5 | 1 | 3250 | 3000 | 1000 | 250 | 250 | 250 | 250 | 250 | 3000 | 3250 | 3250 | 3250 |
| 5 | 2 | 3250 | 3000 | 1000 | 250 | 250 | 250 | 250 | 250 | 3000 | 3250 | 3250 | 3250 |
| 5 | 3 | 2750 | 2500 | 750 | 250 | 250 | 250 | 250 | 250 | 2500 | 3000 | 3000 | 3000 |
| 5 | 4 | 2500 | 1750 | 500 | 250 | 250 | 250 | 250 | 250 | 1750 | 2750 | 2750 | 2750 |
| 5 | 5 | 1500 | 1500 | 500 | 100 | 100 | 100 | 100 | 100 | 1500 | 1500 | 1500 | 1500 |
| 5 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Shasta/Keswick Downstream Releases

CalSim-II models releases of water from storage in the Shasta/Keswick along two arcs, marked in the Figure 6 as C4 (Shasta releases) and C5 (Keswick releases). Model logic associated with these arcs account for minimum flow requirements in the Sacramento River.

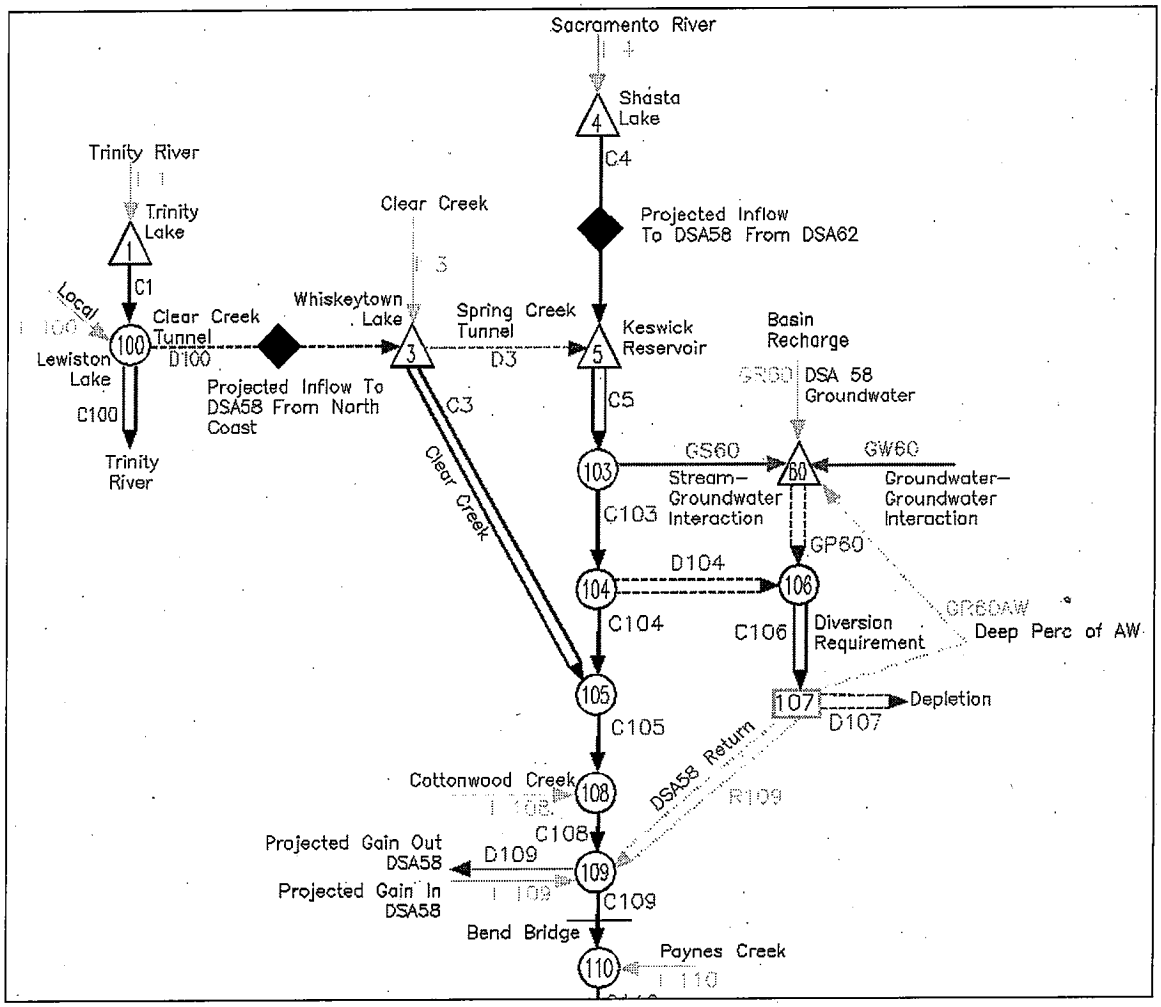


**Figure 6 - Shasta/Keswick Storage and Releases, represented on the CalSim-II schematic through reservoirs 4 and 5 and arcs C4 and C5**

The minimum flow requirement has three parts: (1) the Keswick Temperature Requirement, (2) the Stability Flow Requirement, and (3) the AFRP requirement. The Keswick Temperature Requirement is based upon the storage in Lake Shasta at the end of September. These values are taken from a look-up table[24] and applied continuously throughout the year (Table 5). Temperature requirements are applied in all CalSim-II model steps (D1485 through SDIP).

[24] ... \Run\Lookup\keswick_tempcntrl.table

The Stability Flow requirement exists to maintain the stability of the downstream levee systems against sloughing that could occur as a result of rapid, dramatic declines in river levels. If outflows from Shasta fall below a threshold, the current month's reservoir release must be maintained at a certain fraction of the previous month's reservoir release to sustain the structural integrity of the earthen riverbanks. The thresholds and fractions associated with this regulation are given in Table 6[25], and the Stability Requirement is only invoked when the previous month's flows are below the stability threshold. Stability requirements are applied only in the (b)(2) step and can result in charges to the (b)(2) account.

**Table 5 – Temperature Releases from Shasta Dam (in cfs) corresponding storages**

| Storage in Shasta (TAF) | Oct | Nov | through | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 3,250 | | | | 3,250 | 3,250 | 3,250 | 3,250 | 3,250 | 3,250 |
| 2,000 | 3,250 | | | | 3,250 | 3,250 | 3,250 | 3,250 | 3,250 | 3,250 |
| 2,500 | 3,250 | | | | 4,000 | 5,500 | 5,500 | 6,000 | 6,000 | 4,500 |
| 3,250 | 4,000 | | 3,250 | | 4,250 | 6,350 | 7,000 | 8,500 | 8,000 | 5,500 |
| 3,750 | 4,500 | | | | 4,500 | 7,000 | 8,000 | 9,500 | 9,000 | 6,000 |
| 4,500 | 5,000 | | | | 5,000 | 8,000 | 9,000 | 11,000 | 10,000 | 6,500 |
| >4,500 | 5,000 | | | | 5,000 | 8,000 | 9,000 | 11,000 | 10,000 | 6,500 |

**Table 6 – Stability of Flow requirements for Shasta Dam, coded to represent FWS management of b2 under the May 2003 Department of Interior (b)(2) Decision**

| | Previous month's release from Shasta-Keswick (cfs) | Required Fraction of previous month's flow to maintain in current month |
|---|---|---|
| November | <6,000 | 65% |
| December | <4,500 | 90% |
| January | <4,500 | 80% |
| February | <4,500 | 80% |
| March | <4,500 | 80% |

The Anadromous Fish Restoration Plan (AFRP) flow requirements for the Sacramento River below Shasta and Keswick are based on the previous month's Shasta storage or, between March and September, upon storage plus a forecast of inflows[26] (Table 7). These forecasts are based on 99%, 90%, 75%, and 50% exceedence probabilities for February, March, April, and May through September, respectively. AFRP requirements are applied in the (b)(2) step and can result in charges to the (b)(2) account.

Between the temperature, stability, and AFRP requirements the maximum requirement is not always applied. In conditions when large (b)(2) allocations have been made by the end of January, the AFRP requirement will be relaxed, and the next highest of the temperature and stability flow requirements will be applied[27]. Table 8 explains this

[25] ...\(b)(2)\Run\Lookup\SacStability.table
[26] ...\(b)(2)\Run\Lookup\sacramento_runoff_forecast.table
[27] ...\(b)(2)\Run\(b)(2)Actions\(b)(2)Action1.wresl

decision logic. The bottom two rows in Table 8 refer to "Expected AFRP Costs in January." This value is calculated as the sum of previous costs plus full AFRP flow requirements in January from Whiskeytown, Shasta/Keswick and Folsom/Nimbus. As indicated in the table, requirements that result in (b)(2) costs in excess of 200 TAF by the end of January will be relaxed. This relaxation is performed to conserve (b)(2) water through the spring.

**Table 7 – AFRP flow requirements are specified (in cfs) by the storage in Shasta (TAF). Values marked "**" were not tabulated, and are determined through linear interpolation**

| Shasta Storage (TAF) | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 3250 | 3250 | 3250 | 3250 | 3250 | 3250 | 3250 | 3250 | 3250 | 3250 | 3250 | 4500 |
| 1500 | ** | ** | ** | 3500 | ** | ** | ** | 3250 | 3250 | 3250 | 3250 | ** |
| 1750 | ** | ** | ** | ** | 3500 | ** | ** | 3250 | 3250 | 3250 | 3250 | ** |
| 2000 | ** | ** | ** | 3750 | ** | 3500 | 3500 | 3250 | 3250 | 3250 | 3250 | 6000 |
| 2200 | 3500 | 3500 | 3500 | ** | 3750 | ** | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 2300 | 3750 | 3750 | 3750 | ** | ** | ** | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 2400 | 4000 | 4000 | 4000 | ** | ** | 3750 | 3750 | 3250 | 3250 | 3250 | 3250 | 6000 |
| 2500 | 4250 | 4250 | 4250 | ** | ** | ** | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 2600 | 4500 | 4500 | 4500 | 4000 | ** | ** | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 2700 | 4750 | 4750 | 4750 | 4250 | 4000 | ** | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 2800 | 5000 | 5000 | 5000 | 4500 | 4250 | ** | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 2900 | 5250 | 5250 | 5250 | 4750 | 4500 | ** | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3000 | 5500 | 5500 | 5500 | 5000 | 4750 | 4000 | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3050 | 5500 | 5500 | 5500 | ** | ** | 4250 | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3100 | 5500 | 5500 | 5500 | 5250 | 5000 | 4500 | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3150 | 5500 | 5500 | 5500 | ** | ** | 4750 | ** | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3200 | 5500 | 5500 | 5500 | 5500 | 5250 | 5000 | 4000 | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3300 | 5500 | 5500 | 5500 | 5500 | 5500 | 5250 | 4250 | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3400 | 5500 | 5500 | 5500 | 5500 | 5500 | 5500 | 4500 | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3500 | 5500 | 5500 | 5500 | 5500 | 5500 | 5500 | 4750 | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3600 | 5500 | 5500 | 5500 | 5500 | 5500 | 5500 | 5000 | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3700 | 5500 | 5500 | 5500 | 5500 | 5500 | 5500 | 5250 | 3250 | 3250 | 3250 | 3250 | 6000 |
| 3800 | 5500 | 5500 | 5500 | 5500 | 5500 | 5500 | 5500 | 3250 | 3250 | 3250 | 3250 | 6000 |
| 4552 | 5500 | 5500 | 5500 | 5500 | 5500 | 5500 | 5500 | 3250 | 3250 | 3250 | 3250 | 6000 |

**Table 8 – Minimum flow selection matrix, assuming that the Stability Requirement is evoked**

| Month | (b)(2) Account Condition | Shasta Minimum Flow Requirement |
|---|---|---|
| Dec | (b)(2) costs through Nov. >50 TAF | Max between (Temp, Stability), but not above the AFRP requirement |
| Dec | (b)(2) costs through Nov. <50 TAF | Max (Temp, Stability, AFRP) |
| Jan | (b)(2) costs through Dec. >150 TAF | Max between (Temp, Stability), but not above the AFRP requirement |
| Jan | (b)(2) costs through Dec. <150 TAF | Max (Temp, Stability, AFRP) |
| Jan | (b)(2) costs through Dec. + Expected AFRP Cost in Jan >200 TAF | Max between (Temp, Stability), but not above the AFRP requirement |
| Jan | (b)(2) costs through Dec. + Expected AFRP Cost in Jan <200 TAF | Max (Temp, Stability, AFRP) |

Shasta's storage is treated as part of the larger, integrated Central Valley Project. As such, releases can be made from Shasta in order to fulfill obligations (e.g. delta outflow, instream requirements, export, wheeling, or COA) that are shared among CVP reservoirs. Generally, CalSim-II attempts to keep Shasta, Folsom, and Trinity reservoirs in the same storage zones, thereby balancing the obligations for water with both the capacity of the three dams, and probably the likelihood of being refilled. This balancing, however, is relevant to the 1993 Winter Run Biological Opinion that includes a provision for minimum carryover storage in Lake Shasta of 1.9 MAF at the minimum end-of-September. In CalSim-II, this storage goal is not made explicitly and the fulfillment of the requirement must be judged through an analysis of the output generated at the end of a particular simulation. For the common assumptions baseline, the time-series of simulated September End-of-Month storage is shown in Figure 7.

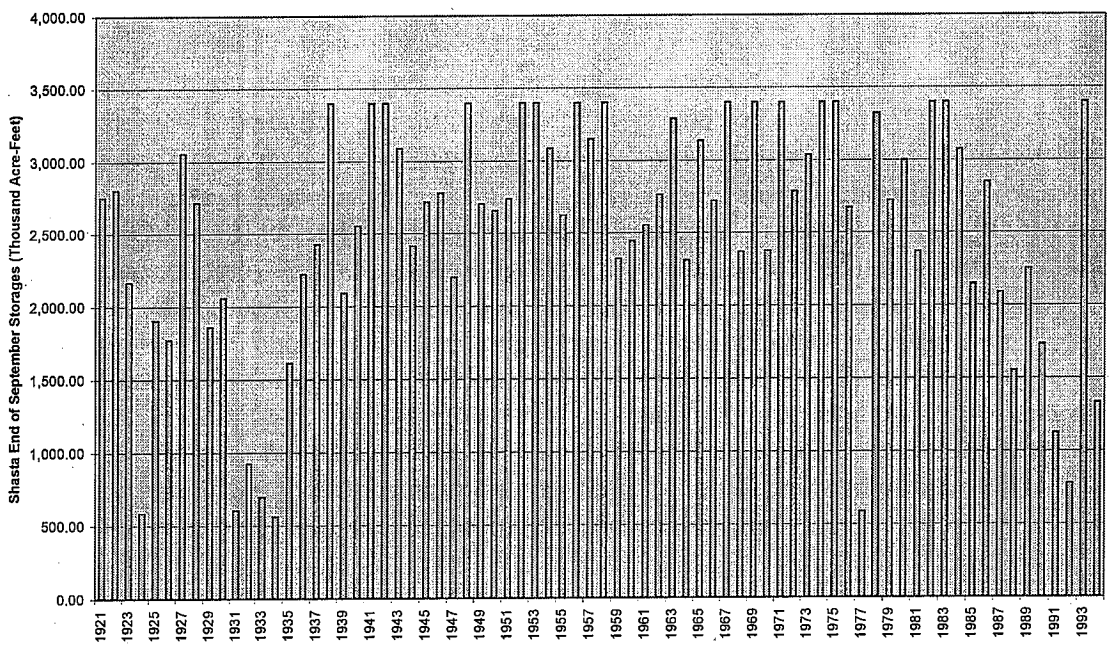


**Figure 7 – End of September storages resulting from Baseline (CA_2020D09D_FutureSDIP_2_1) CalSim-II operations**

## Oroville/Thermalito Downstream Releases

CalSim-II models the combined releases from Oroville and Thermalito along one arc, marked in the Figure 8 as C203. There are three minimum flow requirements imposed on Feather River releases, all of which are expressed in one sub-arc, C203_MIF[28].

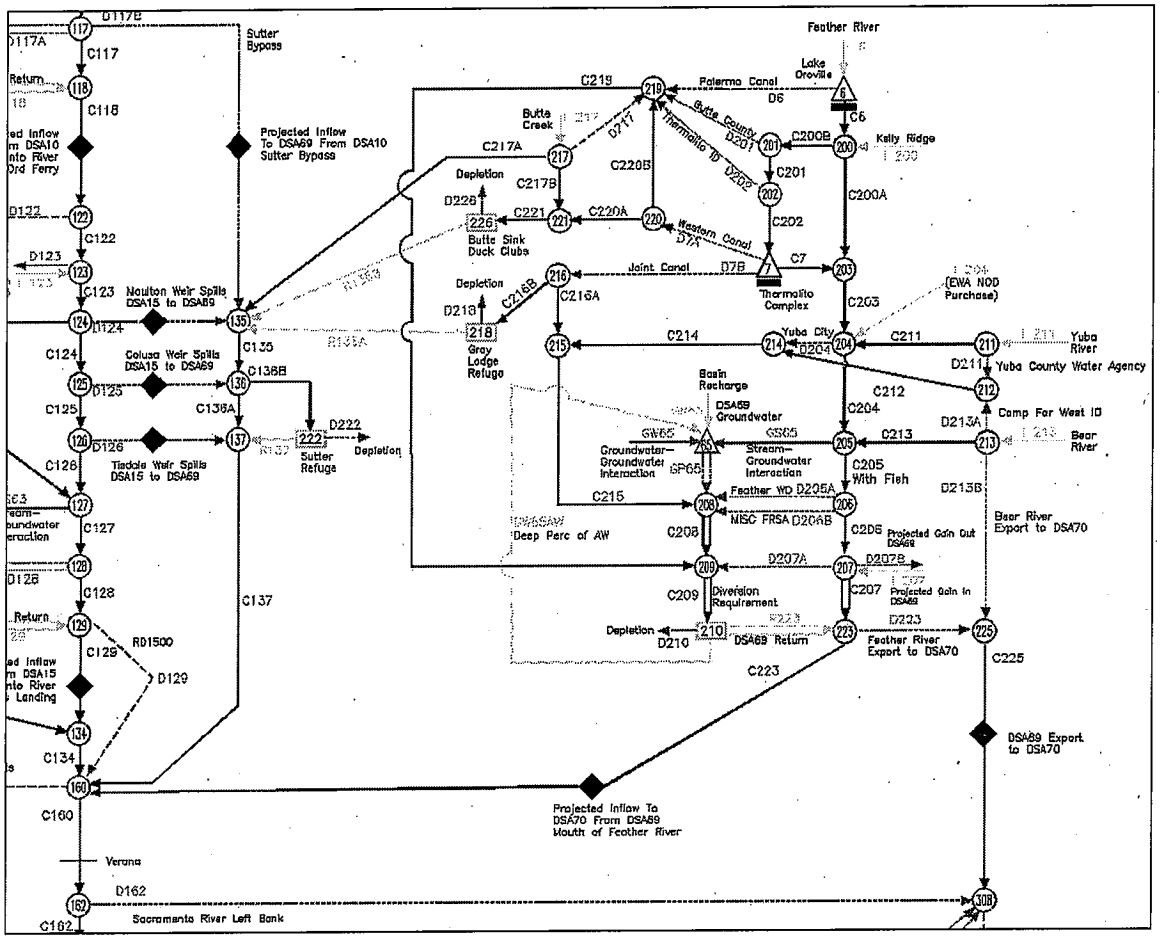


**Figure 8 - Oroville/Thermalito Storage and Releases, represented on the CalSim-II schematic through reservoirs 6 and 7 and arc C6, C7 and (as a combined flow) C203**

If flows on the Feather River exceed an average of 4,000 cfs in October, or 2,500 cfs in November, then the following months (through March) must maintain at least the previous months flow, minus 500 cfs. The only exception to this requirement is in the event of an October or November flood (expressed as Lake Oroville storage in zone 6), in which case no flow requirements are triggered for the following months. CalSim-II attempts to avoid this minimum flow requirement by placing a heavy penalty on flows above 4,000 cfs in October and 2,500 cfs in November.

There is also a minimum instream flow requirement set for the reach of the Feather River between Thermalito and Verona that varies between 750-1,850 cfs depending on the month and the water year.

[28] ...\common\NorthOfDelta\Feather\feather_special.wresl

Finally, between April and September, Lake Oroville is called upon to provide 2,800 cfs in addition to diversions along the Feather River, shown in the CalSim-II schematic as D7A, D7B, D206A, and D206B. Yuba River inflows count toward this requirement. Additionally, the instream flow requirement here is constrained such that the sum of the diversions and instream flow requirement will not exceed the monthly inflow to Oroville Dam. The implication is that maintaining reservoir levels is a higher priority than the satisfaction of downstream environmental flows.

## Folsom/Nimbus Downstream Releases

CalSim-II models releases from Folsom and Nimbus along two arcs, marked in Figure 9 as C8 and C9. The Nimbus release arc is divided into three sub-arcs, to assist in accounting for release requirements.

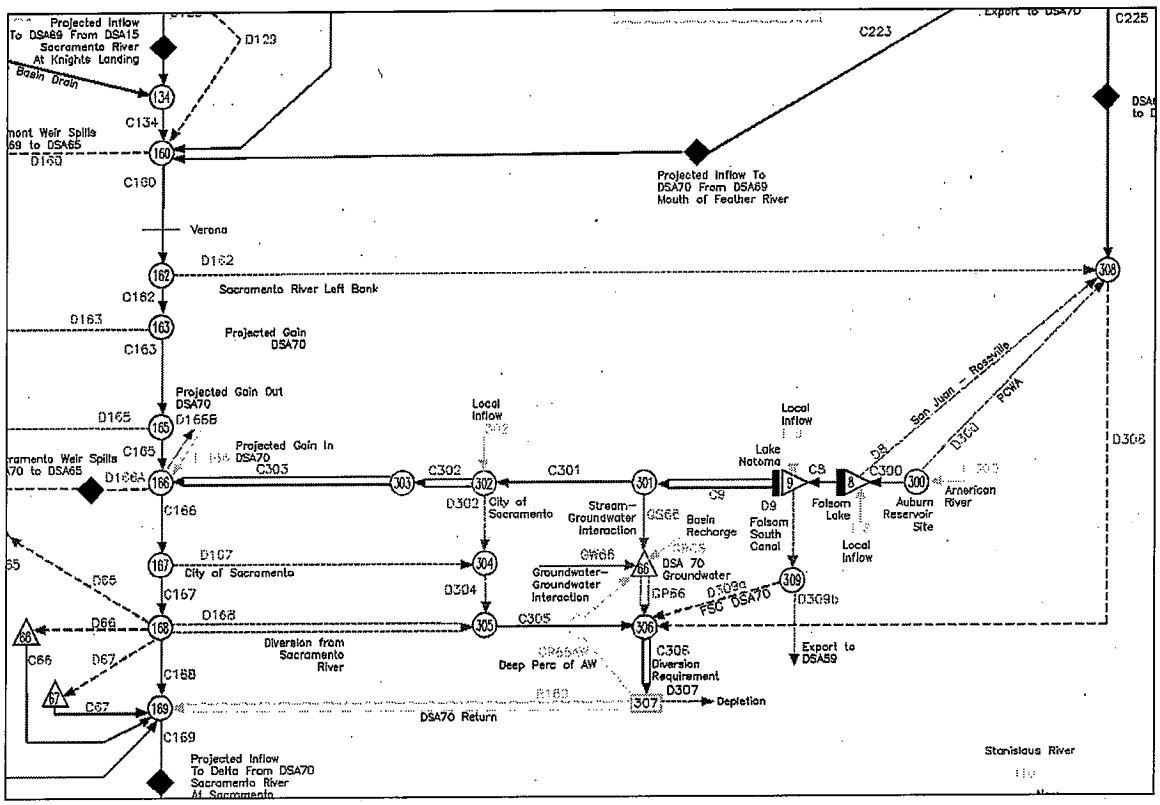


**Figure 9 - Folsom/Nimbus Storage and Releases, represented on the CalSim-II schematic through reservoirs 8 and 9 and arc C8 and C9**

The historic flow requirement at Folsom is based upon "modified D-1400" requirements, as they were modeled within the PROSIM environment[29]. This flow requirement calls for distinct downstream release actions depending on whether the Folsom storage is above or below 200 TAF. If storage is above 200 TAF, CalSim-II bases minimum flow requirements on either storage in Folsom (October – February) or storage plus a forecast of inflows until the end of the water yeas in September (March – September)[30]. Forecasts are based on 99%, 90%, 75% and 50% exceedence probabilities for February, March, April and May through September, respectively. Minimum flows resulting from the application of this logic are given in Table 9.

[29] ...\common\NorthOfDelta\American\NimbusHistMinQ.wresl
[30] ...\D1485\Run\Lookup\american_runoff_forecast.table

**Table 9 - Historic flow requirements through Nimbus Dam, given storages (Oct. – Apr.) or storages plus forecasted inflows (Mar. – Sep.). Values marked "**" were not tabulated, and are determined through linear interpolation.**

| *Folsom Storage (TAF)* | Flow Requirement from Nimbus (cfs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
| *0* | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *80* | ** | ** | ** | ** | ** | 188 | 188 | 188 | 188 | 188 | 188 | 281 |
| *100* | 500 | 500 | 500 | 500 | 500 | 250 | 250 | 250 | 250 | 250 | 250 | 375 |
| *200* | 600 | 500 | 500 | 500 | 500 | ** | ** | ** | ** | ** | 500 | 375 |
| *300* | ** | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | ** |
| *400* | 750 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | 500 | ** |
| *500* | ** | ** | ** | ** | ** | 500 | 500 | 500 | 500 | 500 | 500 | ** |
| *550* | ** | ** | ** | ** | ** | ** | ** | 500 | 500 | 500 | 500 | ** |
| *575* | ** | 1375 | ** | ** | ** | ** | ** | ** | ** | 500 | 500 | ** |
| *600* | 1250 | ** | ** | ** | ** | ** | ** | ** | ** | 500 | 500 | ** |
| *635* | ** | ** | 1000 | 1000 | ** | ** | ** | ** | ** | ** | ** | ** |
| *650* | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | 500 |
| *685* | ** | ** | ** | ** | 1000 | ** | ** | ** | ** | ** | ** | ** |
| *700* | ** | 3000 | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| *760* | ** | 3000 | 3000 | 3000 | ** | ** | ** | ** | ** | ** | ** | ** |
| *770* | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | 1000 |
| *772* | ** | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | ** | ** | ** | ** |
| *800* | 2650 | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | ** | ** | ** | ** |
| *840* | ** | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | ** | | 2000 | ** |
| *960* | ** | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | ** | 2000 | ** | ** |
| *975* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | ** | ** | ** | ** |
| *1000* | 3000 | 3000 | 3000 | 3000 | 3000 | 750 | 750 | ** | ** | ** | 2500 | 2500 |
| *1080* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | 2000 | ** | ** | 2500 |
| *1150* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | ** | 2500 | ** | 2500 |
| *1200* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | ** | 2000 | ** | ** | ** | 2500 |
| *1300* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | 2500 | ** | 3000 | 2500 |
| *1450* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | ** | 2500 | ** | ** | 3000 | 2500 |
| *1500* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | 1750 | ** | ** | ** | 3000 | 2500 |
| *1600* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | ** | 3000 | 3000 | 2500 |
| *1750* | 3000 | 3000 | 3000 | 3000 | 3000 | 1500 | ** | ** | ** | 3000 | 3000 | 2500 |
| *1900* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | ** | ** | 3000 | 3000 | 3000 | 2500 |
| *2250* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | 3000 | ** | 3000 | 3000 | 3000 | 2500 |
| *2300* | 3000 | 3000 | 3000 | 3000 | 3000 | ** | 3000 | 3000 | 3000 | 3000 | 3000 | 2500 |
| *2500* | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 2500 |
| *>2500* | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 2500 |

Alternatively, when Folsom storages are below 200 TAF, CalSim-II defaults to the pre-CVPIA "18 MAR 1953 D-893 American River at H Street" baseflow requirement. This requirement varies by month, and is defined based on the value of the American River D893 Index. The resulting H-Street requirement is given in Table 10.

**Table 10 - H-Street flow requirements for American River under the D1485 Step**

| Month | "H" Street Flow Requirement (cfs) | |
|---|---|---|
| | *D-893 Water Year Type 1* | *D-893 Water Year Type 2* |
| Oct | 500 | 375 |
| Nov | 500 | 375 |
| Dec | 500 | 500 |
| Jan | 250 | 250 |
| Feb | 250 | 250 |
| Mar | 250 | 250 |
| Apr | 250 | 188 |
| May | 250 | 188 |
| Jun | 250 | 188 |
| Jul | 250 | 188 |
| Aug | 250 | 188 |
| Sep | 375 | 281 |

In addition to these historic flow schedules, Stability and AFRP flow requirements are set during the (b)(2) step of CalSim-II's runs. The Stability Flow requirement exists to maintain stable levee systems in the case of low-flow months. If outflows from Folsom fall below a threshold, defined in Table 11[31], then the current month's outflow must maintain a certain fraction of the previous month's outflow to sustain the structural integrity of the earthen riverbanks. Invocation of the stability requirements result in charges against the (b)(2) account.

**Table 11 - Stability Flow requirements for Folsom Dam, coded to represent FWS management of b2 under the May 2003 Department of Interior (b)(2) Decision**

| | Previous month's release from Folsom-Nimbus (cfs) | Required Fraction to maintain in current month |
|---|---|---|
| November | <3,000 | 80% |
| December | <3,000 | 90% |
| January | <3,000 | 75% |
| February | <3,000 | 75% |
| March | <3,000 | 75% |

The AFRP flow requirements, shown above in Table 12[32], are chosen based on storages in Folsom reservoir (October – April) or Folsom storage plus an inflow forecast (March – September). Forecasts for the American River change between February and May based on 99%, 90%, 75%, 50% exceedence probabilities for February, March, April and May through September, respectively.[33]

[31] ...\(b)(2)\Run\Lookup\AmerStability.table
[32] ...\(b)(2)\Run\Lookup\AFRP_AMER.table
[33] ...\(b)(2)\Run\Lookup\american_runoff_forecast.table

**Table 12 – AFRP Flow Requirements for the American River as a function of Folsom storage or, between March and September, storage plus inflow forecasts through September. Values marked "**" were not tabulated, and are determined through linear interpolation.**

| Folsom Storages (TAF) | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 105 | ** | ** | ** | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 375 |
| 125 | 500 | 500 | 500 | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| 200 | ** | ** | ** | 750 | 750 | ** | ** | ** | ** | ** | ** | ** |
| 250 | 1000 | 1000 | 1000 | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| 300 | 1500 | 1500 | 1500 | ** | ** | ** | ** | ** | ** | ** | ** | 500 |
| 350 | 1750 | 1750 | | 1500 | 1500 | ** | ** | ** | ** | ** | ** | 1000 |
| 400 | ** | ** | 1750 | ** | ** | ** | ** | ** | ** | ** | ** | 1250 |
| 450 | ** | ** | ** | 1750 | 1750 | ** | ** | ** | ** | ** | ** | ** |
| 500 | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** | 500 | ** |
| 575 | ** | 2000 | 2000 | 2000 | 2000 | ** | ** | ** | ** | ** | ** | ** |
| 600 | ** | 2000 | 2000 | 2000 | 2000 | ** | ** | 500 | 500 | 500 | 1000 | 1750 |
| 650 | 1750 | 2000 | 2000 | 2000 | 2000 | ** | ** | ** | ** | ** | ** | 1750 |
| 700 | 2000 | 2000 | 2000 | 2000 | 2000 | 500 | 500 | ** | ** | ** | ** | 1750 |
| 725 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | ** | ** | ** | 750 | ** | 1750 |
| 750 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | ** | 750 | 750 | ** | ** | 1750 |
| 775 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | ** | ** | 1000 | 1250 | ** | 1750 |
| 800 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | ** | 1250 | 1250 | 1500 | ** | 1750 |
| 900 | 2000 | 2000 | 2000 | 2000 | 2000 | 750 | 750 | 1750 | 1500 | ** | 1750 | 1750 |
| 950 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | ** | ** | 1750 | ** | 1750 | 1750 |
| 967 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | 1000 | ** | 1750 | ** | 1750 | 1750 |
| 1000 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | 1250 | ** | 1750 | 1750 | 1750 | 1750 |
| 1075 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | 1500 | ** | 1750 | 1750 | 1750 | 1750 |
| 1150 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | 1750 | ** | 1750 | 1750 | 1750 | 1750 |
| 1250 | 2000 | 2000 | 2000 | 2000 | 2000 | 1000 | ** | 2000 | 1750 | 1750 | 1750 | 1750 |
| 1400 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | ** | ** | 2750 | 1750 | 1750 | 1750 |
| 1450 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | ** | 3000 | ** | 1750 | 1750 | 1750 |
| 1500 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | ** | 3000 | 3000 | 1750 | 1750 | 1750 |
| 1750 | 2000 | 2000 | 2000 | 2000 | 2000 | 1500 | ** | 3000 | 3000 | 1750 | 1750 | 1750 |
| 1800 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | 1750 | 3000 | 3000 | 1750 | 1750 | 1750 |
| 2050 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | 2750 | 3000 | 3000 | 1750 | 1750 | 1750 |
| 2100 | 2000 | 2000 | 2000 | 2000 | 2000 | ** | 3000 | 3000 | 3000 | 1750 | 1750 | 1750 |
| 2500 | 2000 | 2000 | 2000 | 2000 | 2000 | 3000 | 3000 | 3000 | 3000 | 1750 | 1750 | 1750 |
| >2500 | 2000 | 2000 | 2000 | 2000 | 2000 | 3000 | 3000 | 3000 | 3000 | 1750 | 1750 | 1750 |

Between the Historic, Stability, and AFRP requirements, the maximum requirement is not always applied. This results from the desire to conserve (b)(2) water for spring releases. In conditions when large (b)(2) allocations have been (or might be) made by the end of January, the AFRP requirement will be relaxed, and the next highest flow

requirement (between Historic and Stability) will be applied.[34] Table 13 explains this decision process.

**Table 13 - Minimum Flow selection matrix, given that the stability requirement is invoked**

| Month | (b)(2) Account Condition | Folsom Minimum Flow Requirement |
|---|---|---|
| Dec | (b)(2) costs through Nov. >50 TAF | Max between (H St., Stability), but not above the AFRP requirement |
| Dec | (b)(2) costs through Nov. <50 TAF | Max (H St., Stability, AFRP) |
| Jan | (b)(2) costs through Dec. >150 TAF | Max between (H St., Stability), but not above the AFRP requirement |
| Jan | (b)(2) costs through Dec. <150 TAF | Max (H St., Stability, AFRP) |
| Jan | (b)(2) costs through Dec. + Expected AFRP Cost in Jan >200 TAF | Max between (H St., Stability), but not above the AFRP requirement |
| Jan | (b)(2) costs through Dec. + Expected AFRP Cost in Jan <200 TAF | Max (H St., Stability, AFRP) |

The bottom two rows in Table 13 refer to "Expected AFRP Costs in January." This value is calculated as the sum of previous costs plus full AFRP flow requirements in January from Whiskeytown, Shasta/Keswick and Folsom/Nimbus. As indicated in the table, requirements that result in (b)(2) costs in excess of 200 TAF by the end of January will be relaxed. This relaxation is performed to conserve (b)(2) water through the spring.

[34] ...\(b)(2)\Run\(b)(2)Actions\(b)(2)Action1.wresl

## New Melones/Goodwin Downstream Releases

CalSim-II models regulatory requirements for the Stanislaus River along three arcs, marked in Figure 10 as C10 (outflow from New Melones Reservoir), C16 (releases from Goodwin Dam), and C527 (a regulatory point upstream of Ripon). All releases from New Melones made for water quality and environmental purposes are routed through Goodwin Dam, and are unavailable for irrigation withdrawals.

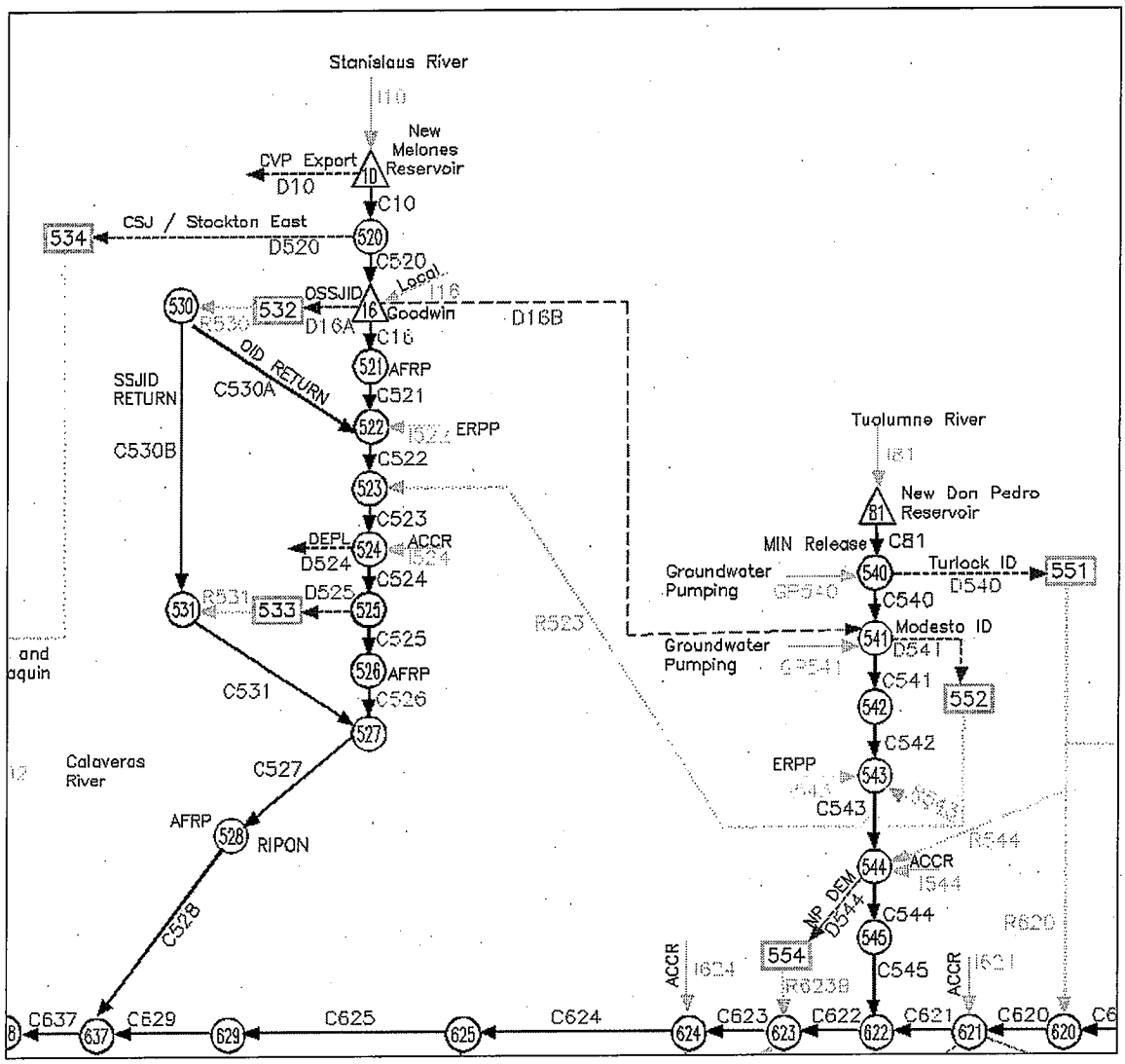


**Figure 10 - CalSim-II schematic for the Stanislaus and Tuolumne Rivers**

There are four general requirements governing minimum flows in the Stanislaus River below Goodwin Dam: dissolved oxygen standards, salinity standards, minimum flows and pulse flows for fish and wildlife in the Stanislaus River, and the Vernalis Adaptive Management Plan (VAMP) pulses.

Dissolved oxygen requirements for the Stanislaus River are defined below both New Melones and Goodwin[35]. As CalSim-II in its present form is incapable of simulating changes in dissolved oxygen concentrations, a surrogate flow prescription is given to represent the D.O. requirements. The flow prescription, shown in Table 14, is applied as part of all CalSim-II cycles.

**Table 14 – Flow based dissolved oxygen criteria for the Stanislaus River[36]**

| Month | Requirement (TAF) |
|---|---|
| June | 13.2 |
| July | 16.2 |
| August | 16.4 |
| December | 14.3 |

The Vernalis salinity requirements for the Stanislaus River are set below Goodwin.[37] If releases from Goodwin are sufficient to meet the standard, storage at New Melones will not be utilized for this purpose; otherwise the requirement will be meet through releases from New Melones. The requirement is based on limiting electrical conductivity (EC) values to not more than 700 and 1000 micromhos/cm for irrigation (April – August) and non-irrigation (September – March) seasons, respectively. CalSim-II approximates the required Stanislaus release by assuming a known salt concentration from several sources of flow in the Lower San Joaquin River system, specifically accretions and returns in the Stanislaus River, main-stem flows of the San Joaquin River before confluence with the Stanislaus River, and the west-side San Joaquin River return flows below the Stanislaus/San Joaquin confluence but upstream of Vernalis. Releases from Goodwin are made such that the aggregate concentration at Vernalis meets water quality standards.

All available water in the Stanislaus may be allocated to satisfy consumptive demands when in fact some portion should have been reserved to meet ecosystem objectives.

Pulse flow requirements for the Stanislaus River are defined as outflow from Goodwin and a point upstream from Ripon (node 525 in Figure 10)[38]. The flow requirement is determined through a three-step calculation. First the six-month New Melones forecast (NMF) is defined as the storage in February plus the sum of inflows through September based on a perfect forecast. Second, following the D1485 CalSim-II cycle, the NMF is used to determine an annual fishery allocation.[39] This allocation is given in Table 15. Finally, the fishery allocation is apportioned between pulse flow and minimum flow schedules, shown in Table 16 and Table 17.

[35] ...\Run\SanJoaquin\Stanislaus\DO.wresl
[36] ...\Run\Lookup\DO.table
[37] ...\common\SanJoaquin\WaterQuality\vernalis_wqmin.wresl
[38] ...\SanJoaquin\Stanislaus\stan_FW_pulse.wresl
[39] ...\Run\Lookup\stan_yr.table

**Table 15 – Allocation to fisheries, based on New Melones Forecasts[39]**

| New Melones Forecast: NMF (TAF) | Fishery Allocation (TAF) |
|---|---|
| 0 | 98 |
| 1,400 | 98 |
| 2,000 | 125 |
| 2,500 | 345 |
| >3,000 | 467 |

**Table 16 – Pulse flow requirement for the Stanislaus River, April 15 – May 15 [40]**

| Fishery Allocation (TAF) | Pulse Requirement (cfs) |
|---|---|
| 0 | 0 |
| 98.9 | 500 |
| >245.7 | 1,500 |

**Table 17 – Minimum flow schedule for the Stanislaus River, in relation to Fishery Allocations [41]**

| | New Melones Forecast (x1,000 acre-feet) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 98.9 | 155 | 200.6 | 256.2 | 311.5 | 410.2 | 466.4 |
| January | - | 125 | 150 | 250 | 275 | 300 | 350 | 400 |
| February | - | 125 | 150 | 250 | 275 | 300 | 350 | 400 |
| March | - | 125 | 150 | 250 | 275 | 300 | 350 | 400 |
| April | - | 250 | 300 | 300 | 300 | 900 | 1,500 | 1,500 |
| May | - | 250 | 300 | 300 | 1,500 | 900 | 1,500 | 1,500 |
| June | - | - | 125 | 200 | 200 | 250 | 800 | 825 |
| July | - | - | 125 | 200 | 200 | 250 | 300 | 625 |
| August | - | - | 125 | 200 | 200 | 250 | 300 | 525 |
| September | - | - | 125 | 200 | 200 | 250 | 300 | 400 |
| October | - | 110 | 110 | 200 | 250 | 250 | 350 | 350 |
| November | - | 200 | 225 | 250 | 275 | 300 | 350 | 400 |
| December | - | 200 | 225 | 250 | 275 | 300 | 350 | 400 |

The 1995 WQCP Vernalis minimum flow requirement is defined as soft constraints on releases from New Melones.[42] Releases from New Melones for Vernalis minimum flows are released through Goodwin, and cannot be diverted for other purposes. The standard is determined by (a) the San Joaquin water year type, (b) the day weighted average X2 requirement at Roe Island, Chipps Island and the Sacramento – San Joaquin River confluence (Table 18), (c) a restriction on flows at Goodwin and Ripon (1500 cfs) and (d) a cap set on the sum of New Melones releases between February and June. The New Melones outflow restriction is based on the New Melones forecast as shown in Table 19. Releases from New Melones are designed to make up any deficit in the Vernalis minimum flow requirement, up to release restrictions at New Melones, Goodwin, and Ripon.

[40] ...\Run\Lookup\stan_pulse.table
[41] ...\Run\Lookup\stan_monfish.table
[42] ...\SanJoaquin\Vernalis\vernalis_min.wresl

**Table 18 – Vernalis Requirement, by Water Year and X2 Position**

| San Joaquin Water Year Type | IF X2 is East of Chipps Island, Vernalis Requirement (cfs) | IF X2 is West of Chipps Island, Vernalis Requirement (cfs) |
|---|---|---|
| 1 | 2130 | 3420 |
| 2 | 2130 | 3420 |
| 3 | 1420 | 2280 |
| 4 | 1420 | 2280 |
| 5 | 710 | 1140 |

**Table 19 – Annual Release Restriction at New Melones[43]**

| New Melones Forecast (TAF) | Release Restriction at New Melones (TAF) |
|---|---|
| 0 | 0 |
| 1,400 | 0 |
| 2,000 | 0 |
| NMF ≥ 2,500 | 1,000 |

VAMP are target flows in the San Joaquin River at Vernalis during April and May, the obligation for which is shared by water users on all of the eastside San Joaquin River tributaries and the beneficiaries of the exchange pool at Mendota. In the event that other CalSim-II operations leave a deficit in the VAMP account, a portion of the deficit must be offset by release to the lower Stanislaus below Goodwin Dam. Table 20 identifies the VAMP obligation of the Stanislaus River water users and other VAMP regulated rivers, as a function of the VAMP deficit.

**Table 20 – New Melones release requirements (TAF), relative to VAMP deficits**

| VAMP Deficit (TAF) | Merced ID: Merced River | OID: Stanislaus River | Exchange: Mendota Pool | MID/TID: Tuolumne River |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 25 | 25 | 0 | 0 | 0 |
| 35 | 25 | 10 | 0 | 0 |
| 40 | 25 | 10 | 5 | 0 |
| 50 | 25 | 10 | 5 | 10 |
| 61.5 | 36.5 | 10 | 5 | 10 |
| 66.1 | 36.5 | 14.6 | 5 | 10 |
| 68.4 | 36.5 | 14.6 | 7.3 | 10 |
| 73 | 36.5 | 14.6 | 7.3 | 14.6 |
| 81.5 | 45 | 14.6 | 7.3 | 14.6 |
| 84.9 | 45 | 18 | 7.3 | 14.6 |
| 86.6 | 45 | 18 | 9 | 14.6 |
| 90 | 45 | 18 | 9 | 18 |
| 100 | 55 | 18 | 9 | 18 |
| 104 | 55 | 22 | 9 | 18 |
| 106 | 55 | 22 | 11 | 18 |
| Deficit ≥ 110 | 55 | 22 | 11 | 22 |

[43] ...\Run\Lookup\stan_yr.table

CalSim-II sequences the access to storage in New Melones Reservoir to meet these various water quality and environmental flow requirements. The general sequence of access is as follows:

1) In the first CalSim-II model cycle, irrigators access storage and inflows to New Melones and Goodwin, up to their current monthly demand.
2) Throughout the remaining model cycles, inflows to and storage in New Melones and Goodwin are made available for water quality and environmental flow requirements in the Lower Stanislaus River and in the Delta.

This sequencing suggests that water delivery objectives are paramount relative to environmental flow requirements. The implication is that all available water may be allocated to satisfy consumptive demands when in fact some portion of available storage should have been reserved to meet ecosystem objectives.

## Delta Outflow Requirements

CalSim-II represents the basic outflow requirements from the Sacramento-San Joaquin Delta through a demand arc marked as D407 in

Figure 11. Generally, the D407 flow requirement is a composite of the X2 requirement and other Delta outflow standards. This standard is set by evaluating (1) the Minimum Required Delta Outflow (MRDO) in concert with either (2a) the ANN Delta Outflow Requirement or (2b) the G-Model. In the CalSim-II model evaluated for this review, the final Delta outflow requirement is the maximum between MRDO and the ANN.

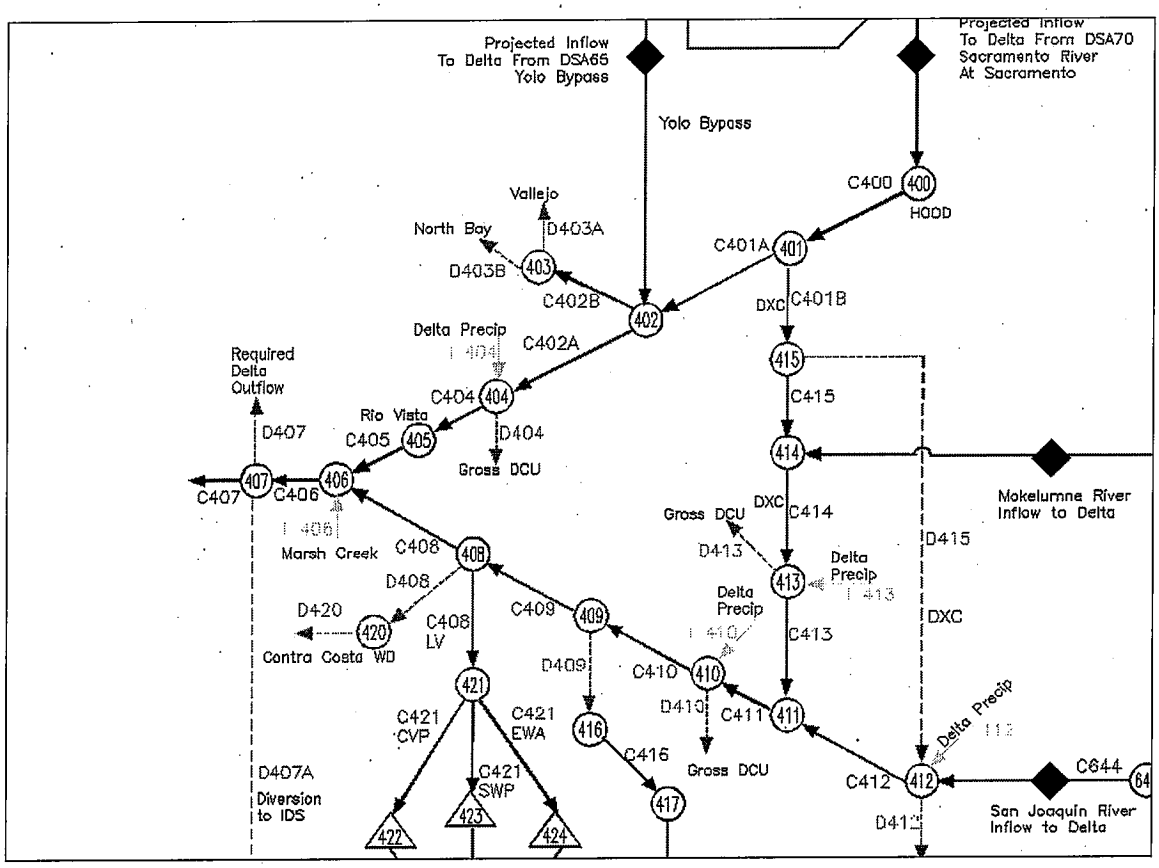


**Figure 11 - CalSim-II Representation of the Sacramento-San Joaquin Delta**

The Minimum Required Delta Outflow is calculated by evaluating eight separate flow requirements:

| | | |
|---|---|---|
| i. | Striped Bass Survival/Spawning | (D1485 Flow Requirement, for (b)(2) accounting) |
| ii. | Suisun Marsh Flow Requirement | (D1485 Flow Requirement, for (b)(2) accounting) |
| iii. | 60-day Suisun Marsh Flow Requirement | (D1485 Flow Requirement, for (b)(2) accounting) |
| iv. | Flood Envelope Flow Requirement | (D1485 Flow Requirement, for (b)(2) accounting) |
| v. | X2 at Roe Island/Port Chicago | (D1641, (b)(2), and SDIP Flow Requirement) |
| vi. | X2 at Chipps Island | (D1641, (b)(2), and SDIP Flow Requirement) |
| vii. | X2 at the Sacramento-San Joaquin confluence | (D1641, (b)(2), and SDIP Flow Requirement) |
| viii. | Absolute Minimum Delta Outflow | (D1641, (b)(2), and SDIP Flow Requirement) |

These requirements specify (a) the quantity of Delta outflow required to satisfy the requirement, (b) the day the requirement begins, and (c) the day the requirement ends. A composite of these standards is sent by CalSim-II to an external FORTRAN routine that determines the minimum required Delta outflow quantity by arraying the flow requirements across the days in a month, finding the maximum value for each day and averaging these daily maximums to get a monthly value. This procedure is required because CalSim-II runs on a monthly time step. While this is common for water resource planning models, it complicates the simulation of environmental regulation in the Delta which has been designed to manage day to day conditions in the system.

These standards are more related to protecting consumptive uses than creating optimal environmental conditions.

The first four flow requirements are considered by MRDO during the D1485 model cycle (requirements i-iv), but not during subsequent cycles. Increases in reservoir releases or decreases in South of Delta exports that result from changes to these policies during later model cycles are charged to the (b) (2) account.

**Table 21 – Striped Bass survival and spawning Delta outflow schedules**

| | Delta outflow schedule (cfs) by water year designation | | | | | | |
|---|---|---|---|---|---|---|---|
| | W[44] (1) | AN[44] (2) | D[44] (3) | C[44] (4) | Dry-Dry[44] | Wet-Dry[44] | Low Snow[45] |
| October | 4000 | 4000 | 4000 | 4000 | 3000 | 2500 | 2500 |
| November | 4500 | 4500 | 4500 | 4500 | 3500 | 2500 | 2500 |
| December | 4500 | 4500 | 4500 | 4500 | 3500 | 2500 | 2500 |
| January | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| February | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| March | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| April | 6700 | 6700 | 6700 | 6700 | 6700 | 6700 | 6700 |
| May | 14000 | 14000 | 11400 | 4300 | 3300 | 4300 | 6500 |
| June | 14000 | 10700 | 9500 | 3600 | 3100 | 3600 | 5400 |
| July | 10000 | 7700 | 6500 | 3200 | 2900 | 3200 | 3600 |
| August | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |
| September | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 | 2500 |

The Striped Bass survival and spawning requirement defines Delta outflows from May 6th – April 14th (excluding April 15th – May 5th). The level of flow required is set by three indices: the D1485 Fish and Wildlife Standards Index[46], the D1485 Subnormal Snowmelt Index[47], and the D1485 Project Deficiency Index[48]. Under normal circumstances, the flow requirement corresponds to the D1485 water year index, shown in the first four columns of Table 21. For sequential dry water years, the requirement

[44] ...\D1485\Run\Lookup\NdoBass.table
[45] ...\D1485\Run\Lookup\NdoBassSnow.table
[46] ...\D1485\Run\Wytypes\wytypes.wresl [NOTE: defined in wresl code as the product of 2 other wytypes]
[47] ...\D1485\Run\Lookup\wytypeSnow.table
[48] ...\D1485\Run\Lookup\wytypeDefic.table

goes to the Dry-Dry schedule. In a dry year following a wet year, the Wet-Dry schedule is invoked. If the water year type is either dry or critical *and* there is a low snowpack forecast (as determined by the D1485 Subnormal Snowmelt Index) the Low Snow schedule in the final column governs the standard.

When the D1485 Project Deficiency Index is triggered (an index value of 1), then the April 1st and 14th schedule can be reduced to 2,500 cfs. Likewise, in a critical D1485 water year the same reduction is allowed.

The Suisun Marsh flow requirement is set based on two water year indices: the D1485 Fish and Wildlife Standards Index[49], the D1485 Subnormal Snowmelt Index[50]. This requirement specifies a default 2,500 cfs Delta outflow flow throughout the year. Criteria for deviating from the default flow requirement are specified in Table 20.

**Table 20: Conditional Wet Water Year Suisun Marsh spring flows**

| D1485 F&W Index | D1485 Subnormal Snowmelt Index | Flow Requirement | Period of Flow Requirement |
|---|---|---|---|
| Wet | Low Snow | 10,000 cfs | February - April |
| Wet | Not Low Snow | 10,000 cfs | February - May |

The 60-day Suisun Marsh Flow Requirement operates between January and April. This requirement is 2,500 cfs by default. In non-wet (i.e. index $\neq$ 1) and non-dry (i.e. index $\neq$ 4) water years, the flows are required to be 12,000 cfs for two months between January and April. The months do not have to be sequential, and CalSim-II accounts for the months during this period when the requirement is met.

The three-reservoir Flood Envelope requirement is set by North of Delta storage conditions. In the case that two of the North of Delta projects (Shasta, Folsom, and/or Oroville) have storage in zone 5 (high/spill storage reservoir zone), Delta outflow is required to be 6,600 cfs. Otherwise, the flow requirement defaults to 2,500 cfs.

The Post-D1641 X2 Outflow Requirements (requirements v-viii) are calculated by tracking the 2ppt (X2) bottom isohaline line between the months of February and June. CalSim-II calculates a net monthly flow requirement for three locations (Roe Island/Port Chicago at river mile 39, the Sacramento-San Joaquin Confluence at river mile 50, and Chipps Island at river mile 74).

The first step in setting the X2 requirements is determining where the X2 isohaline line is situated at the beginning of a month or period (BOP). This is determined using the Kimmerer-Monismith equation[51], which references the previous month's North of Delta outflow (NDO) which enters the Delta and the X2 location at the beginning of the previous month (Equation 1).[52]

[49] ...\D1485\Run\Wytypes\wytypes.wresl [NOTE: defined in wresl code as the product of 2 other wytypes]
[50] ...\D1485\Run\Lookup\wytypeSnow.table
[51] It is important to note that this regression equations were develop using data from historic Delta export conditions and that future changes that include dramatic changes in Delta exports may compromise the use of these relationships.
[52] ...\Run\Delta\MRDO\X2\X2req.wresl

| | |
|---|---|
| **Equation 1** | $X2_{BOP} = \mathbf{122.2} + \mathbf{0.3278} * X2\text{-}Location_{\text{beginning of previous month in kilometers}} - \mathbf{17.65} * log_{10}(NDO_{\text{previous month in cubic feet per second}})$ |

If the calculated BOP X2 location is greater than 66.3 km (river mile 41) then the calculation of the Roe Island requirement is invoked. If the BOP X2 position is at, or below the 66.3 km point, then the Roe Island requirement is bypassed. If the Roe Island X2 requirement is triggered, the number of days that the Roe Island X2 constraint is expected to be a controlling Delta outflow requirement is referenced from a lookup table.[53] This number varies by month and by water year. The Delta outflow required to satisfy Roe Island is capped at 29,200 cfs, and is calculated Equation 2.[54]

| | |
|---|---|
| **Equation 2** | $Q_{\text{Roe Island Requirement}} = 10 \wedge [(\mathbf{122.2} + \mathbf{0.3278} * X2\text{-}Location_{\text{beginning of previous month}} - \mathbf{64}) / \mathbf{17.65}]$ |

If Roe Island is triggered, a further calculation (Equation 3)[55] determines where X2 will be situated at the end of the month as a result of meeting the Roe Island outflow requirement.

| | |
|---|---|
| **Equation 3** | $X2\text{-}Location_{\text{Post Roe Island}} = \mathbf{122.2} + \mathbf{0.3278} * X2\text{-}Location_{\text{beginning of month}} - \mathbf{17.65} * Log_{10}(Q_{\text{Roe Island Requirement}})$ |

In the case that Roe Island standard is invoked, the number of days in which the Chipps Island requirement controls the Delta outflow requirement (same lookup table as the Roe Island standard)[56] is reduced by the number of Roe Island days. The Chipps Island flow requirement is capped at 11,400 cfs, and is calculated using Equation 4[57].

| | |
|---|---|
| **Equation 4** | $Q_{\text{Chipps Island Requirement}} = 10 \wedge [(\mathbf{122.2} + \mathbf{0.3278} * X2\text{-}Location_{\text{Post Roe Island}} - \mathbf{74}) / \mathbf{17.65}]$ |

Equation 5[58] then determines where X2 will be situated as a result of meeting the Chipps Island outflow requirement.

[53] ...\D1641\Run\Lookup\x2days.table
[54] ...\Run\Delta\MRDO\X2\X2req.wresl
[55] ...\Run\Delta\MRDO\X2\X2req.wresl
[56] ...\D1641\Run\Lookup\x2days.table
[57] ...\Run\Delta\MRDO\X2\X2req.wresl
[58] ...\Run\Delta\MRDO\X2\X2req.wresl

| | |
|---|---|
| **Equation 5** | $X2\text{-}Location_{Post\ Chipps\ Island} = \mathbf{122.2} + \mathbf{0.3278} * X2\text{-}Location_{beginning\ of\ month} - \mathbf{17.65} * Log_{10}(Q_{Chipps\ Island\ Requirement})$ |

The Sacramento-San Joaquin Confluence flow requirement is reduced by the number of days in which either the Roe or Chipps Island requirements are being met (the greater between the two). In the case that Roe Island is not triggered, then the number of days in which the Confluence requirement would be a controlling outflow requirement (same lookup table as the Roe and Chipps Island standards)[59] is reduced by the number of Chipps Island days. The Confluence flow requirement is capped at 7,100 cfs, and is calculated using Equation 6[60].

| | |
|---|---|
| **Equation 6** | $Q_{Chipps\ Island\ Requirement} = 10 \wedge [(\mathbf{122.2} + \mathbf{0.3278} * X2\text{-}Location_{Post\ Roe\ Island} - \mathbf{74}) / \mathbf{17.65}]$ |

To generate the final X2 requirement, the Roe Island requirement is assumed to begin on day 1 and end after the pre-determined period of time. Any remaining Chipps Island requirements begin on the day after the Roe Island requirement is met. Lastly, any Sacramento-San Joaquin Confluence flow requirements begin on the day after the Chipps Island requirements are met. The Confluence requirement then continues through to the end of the month.

Observation of the results of CalSim-II evaluated during this review reveal that during May and June of the 1924, 1931, 1939, 1976, 1977, 1990, 1991 and 1994 water years, zero X2 days were required, apparently because the projected 40-30-30 Sacramento River Index fell below 8.1 MAF in the month of May. During these situations, a 4,000 cfs minimum flow standard is maintained.

The ANN Delta Outflow Requirement is computed in an external FORTRAN routine (an Artificial Neural Network). Current physically based models, such as the DSM-II, report salinity levels as a function of Delta inflows and exports, and not visa-versa. CalSim-II's ANN was designed to reverse this functional relationship in a procedure that would otherwise be a lengthy iterative process. The ANN bases its decisions on the current month's flow (the only variable), on antecedent flow conditions, and on the current level of salinity at each station. Standards that emerge from the ANN are designed to protect water quality at various points throughout the Delta. These standards are more related to protecting consumptive uses than creating optimal environmental conditions

CalSim-II takes a composite of all of the preceding flow standards in order to arrive at the minimum Delta outflow assigned to arc D407 shown in the schematic found in Figure 11.

[59] ...\D1641\Run\Lookup\x2days.table
[60] ...\Run\Delta\MRDO\X2\X2req.wresl

## Full Environmental Compliance CalSim-II Formulation Work Plan

Based on the insights gleaned from this environmental review, it is possible to begin sketching out a work plan for developing a legal compliance formulation of the CalSim-II model. Before launching in to this exercise, however, it is worth forwarding a few general impressions that can place the recommended work plan items in a proper context.

1. Any water resources model, including CalSim-II, can be improved through continued refinement of its underlying assumptions. The following work plan is offered in the spirit of constructively contributing to continued improvements to the CalSim-II model.
2. Based on the sub-set of CalSim-II logic reviewed for this report we are confident in the validity of our conclusions that we used them to motivate the following proposed work plan.
3. Like most water resource planning models, CalSim-II is path dependent. Much of the model logic governing the simulated system operation is governed by the state of the system at a particular moment in time, and this state will evolve differently under alternative assumptions about the environmental regulations governing system operations. This means that examining model code is not a sufficient method for understanding the implications of different model formulations. In the end, changes in the code must be implemented and the implications of these changes must be measured by examining model output. For these reasons recommend that the CalSim-II development team implement this workplan and evaluate the magnitude of potential changes in model output.

With these impressions on the table, our conclusion after having completed the environmental review are that the work plan for creating a full environmental compliance formulation should focus on:

- Removing all vestiges of perfect foresight from the definition of environmental regulations governing system operations;
- Revising the (b)(2) accounting logic to align it with what we consider to be the current interpretation of the CVPIA; and
- Introducing a minimum flow standard from the San Joaquin River.

### Removing Perfect Foresight from the Definition of Environmental Regulations

In developing the work plan for this CalSim-II model improvement, we adopt the assumption implicit in the definition of environmental regulations as constraints on system operations, namely that they are of a higher priority than any other water management objectives in the system. As such, at any particular moment in a CalSim-II simulation, the model should anticipate that environmental regulations should be met to the fullest possible extent, unless and until conditions dictate that environmental regulations can be relaxed. This is not the approach taken in the current CalSim-II formulation, which relies on water year indices defined during the February or March time step, to determine if environmental regulations can be relaxed.

For example, consider the definition of the obligation associated with the (b)(2) account as described in Table 1. In February, with the benefit of perfect foresight, a

determination is made regarding whether the annual (b)(2) obligation is 800 TAF, 700 TAF, or 600 TAF. In order to meet the full environmental compliance standard and honor the top priority assumption implicit in the definition of environmental constraints, the strictest possible regulations must be anticipated until enough information is available to decide otherwise. In much the same way that CalSim-II uses forecasts to introduce uncertainty into its promised water deliveries, uncertainty needs to influence the establishment of environmental regulations.

As discussed above, in calculating the value of WSI during the February time step, CalSim-II uses the level of precipitation that has been exceeded 99% of the time during the remaining months of the water year in order to forecast what reservoir inflow will be available for allocation during the coming months. This threshold drops to 90% during the March time step, 75% during the April time step, and 50% during the May time step. This is a prudent risk management strategy, as it assumes the worst when much is still unknown about what the future holds. A corollary to this prudent posture is to also assume that environmental constraints will be at their most stringent when much is still unknown about what the future holds. Perfect foresight is not consistent with this risk management posture.

To satisfy a full environmental compliance standard, all of the indices used in CalSim-II need to be calculated dynamically based on prudent forecasts about what the future may hold. In February the question should be what are the environmental constraints that will be in place going forward assuming that future inflows associated with the level of precipitation exceeded 1% of the time during the remainder of the water year is used to forecast the relevant indices. The answer to this question will surely be the most stringent set of environmental constraints. As time passes and the future becomes more certain then the level risk tolerance related to calculating water year indices can be increased. During the March time step the question would be what are the environmental constraints that will be in place going forward assuming that future inflows are associated with the level of precipitation exceeded 10 % of the time during the remainder of the water year are used to update the relevant indices. In April the threshold would drop to 25% and then to 50% in May. By applying this corollary to the risk tolerance already applied to project water supply availability, the top priority environmental constraints would not be weakened until there was justification for doing so.

Under this formulation, the calculation of the water supply index and use of the WSI-DI and DelCar Curves to translate WSI into a promised level of deliveries to meet current water demands does not change. During years when perfect foresight allowed for an early weakening of environmental constraints under the old formulation, however, under the new formulation the promised deliveries will be subject to more stringent environmental constraints during some portion of the February to June period. This may mean that CalSim-II could fail to meet the water delivery promises generated by the current set of risk management curves (the red dot in Figure 3). In keeping with the risk tolerance philosophy implicit in these curves, they should be retrained as part of the full environmental compliance formulation in the event that significant delivery shortfalls materialize so that less water is promised to other water uses in the system.

***Activity 1: Internalize the calculation of water year indices used to set environmental regulations.***
This activity involves moving the values of water year indices used to set environmental regulations from external look-up tables where they are stated with perfect foresight into the actual WRESL code where they will be updated continuously based on forecasted inflows.

***Activity 2: Define risk tolerance posture with respect to anticipated environmental regulations.***
We propose that the 1% exceedence probability of forecasted inflows be used for the months of October-February. This will assure that the strictest possible environmental regulations will be anticipated during that period when large amounts of uncertainly exist about the future. As a corollary to the risk tolerance implicit in the forecasts used to support water allocation, assume that the 10% exceedence inflow will be used in March, 25% in April, and 50% in May. By June that water year index can be set definitively for the remainder of the water year.

***Activity 3: Construct the forecasted inflow data tables that will drive the continuous calculation of water year indices.***
The forecasted inflows used to support water allocation are read in to CalSim-II from an external file. A similar set of anticipated inflow tables would need to be developed to capture the risk tolerance posture adopted for anticipating environmental regulations.

***Activity 4: Implement WRESL code required to adjust environmental regulations based on the continuous evolution of water year indices.***
In the current version of CalSim-II, the environmental regulations create a pre-determined constraint on simulated system operations. The new formulation would require WRESL code to look-up the regulations associated with an evolving series of water year indices.

***Activity 5: Update the WSI-DI and DelCar curves to reflect the change in underlying constraint set.***
As the underlying constraint set used to develop the WSI-DI and DelCar curves, which was based on the application of perfect foresight in setting environmental constraints, will be modified by implementing the preceding activities, it may be necessary to update these risk tolerance defining curves as higher environmental flows will likely be required during the late winter and early spring months.

REVISING THE (B)(2) ACCOUNTING LOGIC
While the method used in applying environmental actions against the (b)(2) account has been the subject of legal and administrative wrangling since the passage of CVPIA in 1992, we believe that the logic employed in CalSim-II to capture the currently accepted accounting methodology is not entirely consistent with the current legal interpretation of the Act. We recognize that this conclusion derives from our interpretation of current law, so it is probably worthwhile to articulate our position on this point.

First, we believe that the intent of (b)(2) was to rededicate a portion of the CVP yield back to fish and wildlife enhancement objectives, primarily the restoration of anadromous fish. While courts have found that Delta water quality actions, which benefit Delta resident fish and consumptive water users relying on water drawn from the Delta, could be considered as acceptable charges against the (b)(2) account, they stipulated *"as long as the allocation gives effect to the hierarchy of purposes established in section 3406(b)(2)"*. Here we believe the intent was clear as Section 3406(b)(2) of the Central Valley Project Improvement Act states that the CVP will:

> "dedicate and manage annually 800,000 acre-feet of Central Valley Project yield for the **primary purpose** of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by this title; to assist the State of California in its efforts to protect the waters of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; and to help to meet such obligations as may be legally imposed upon the Central Valley Project under State or Federal law following the date of enactment of this title, including but not limited to additional obligations under the Federal Endangered Species Act."

We also believe that fish, wildlife, and habitat restoration purposes and measures specifically include the anadromous fish doubling goal included in the Act.

The current CalSim-II formulation turns this notion of primacy upside down by fully changing water quality actions to (b)(2), as well as other non-fish motivated actions, while using fish and wildlife actions to make up any remaining obligations to the (b)(2) account. This stems from the fact that the D-1641 step is run before the (b)(2) step and that all changes in the release and export metrics associated with the difference between the D-1485 and D-1641 steps are charged to (b)(2) with perfect foresight for the water year. In addition, in reviewing various environmental regulations we discovered several other actions of questionable fish and wildlife value that are charged to (b)(2). All this occurs before any fish and wildlife (b)(2) action occurs.

We propose an alternative course of action that envisions the implementation of a new step in the CalSim-II formulation. In keeping with its implicit focus on anadromous fish recovery, this new step is provisionally referred to as the salmon step. The sequence of (b)(2) actions currently used in CalSim-II, as shown in Table 21, is a good starting point for developing the elements of the salmon step. We feel that the highest priority should be assigned to AFRP releases (currently priority 3) as these are designed specifically to meet the anadromous fish-doubling target that was also part of the CVPIA. If this were the case, the type of limitations on AFRP releases that are contained in Table 8 and Table 13 would be unnecessary as these are intended to minimize AFRP flows when significant credits to the (b)(2) account can be derived from the D-1641 step.

A second level of priority would be assigned to the VAMP export priorities (current priority 2), as well as the pre- and post-VAMP restrictions (currently priorities 7 and 4 respectively). As all of these actions would occur after the October to March period during which AFRP flows would be implemented, it should be possible to consider the three components of the VAMP export limitations as a single action.

The final actions in the new salmon step would include the export ramping and the 3000 cfs export limit actions anticipated for the month of June. As these occur after the VAMP export restrictions, a decision will be made in June as to whether they are necessary.

| Action Description | Priority of Action | Reserve* for Action (taf) | Balance† Req'd to Trigger Action (taf) | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WQCP Support (D-1641) | 1 | | | | | | | | | | | | | | |
| AFRP Releases | 3 | | 1 | | | | | | | | | | | | |
| Export Reductions (150 taf) | 6 | 150 | 1+2+3+4+5+6 | | | | | | | | | | | | |
| VAMP Export Restrictions | 2 | 115 | | | | | | | | | | | | | |
| Post VAMP Export Restrictions | 4 | 45 | 1+4 | | | | | | | | | | | | |
| Export Ramping | 5 | 60 | 1+5 | | | | | | | | | | | | |
| 3000 cfs Export Limit | 2 | | | | | | | | | | | | | | |
| Pre VAMP Export Restrictions | 7 | 40 | 1+2+4+4+7 | | | | | | | | | | | | |
| Export Reductions (35 taf) | 8 | 35 | | | | | | | | | | | | | |

* Average reserve amount. Actual reserves may depend on water year type and/or other hydrologic conditions. Reserves for multi-month actions represent the amount required to complete the entire actions.

† (b)(2) balance after accounting for past costs and current month WQCP(D-1641) support. Values refer to the sum of the reserve amounts associated with the action priorities.

A couple of clarifying points are useful at this point in the discussion. Based on the removal of perfect foresight from the establishment of environmental regulations described above, the exact (b)(2) obligation will not be known as the AFRP actions are implemented between October and March. If this creates a situation whereby AFRP actions result in greater charges against (b)(2) than are finally called for based on the evolution of water year indices, the excess will be changed against the (b)(2) account during the following water year.

Second, several local environmental regulations that are of questionable fishery value, namely the stability criteria on the Sacramento and American Rivers and the diversion of water that would otherwise spill in the Trinity system, are currently charged against (b)(2). In implementing the new salmon step, these charges would not be allowed.

Finally, as the proposed salmon actions are implemented sequentially, there is no need to define and manage reserves and triggers as is the case in the current (b)(2) step. The proposed anadromous fish related actions would simply be implemented in sequence until the (b)(2) obligations is satisfied.

Following the completion of the new salmon CalSim-II step, the current D-1641 step would be implemented. This step contains regulatory drivers related to Delta water quality to protect Delta resident fish and water users who draw water from the Delta. It seems to us that these two drivers are so tightly bound in the D-1641 step that it is unreasonable to separate actions driven by fishery objectives from those driven by consumptive water needs. Therefore we acknowledge that should any remaining (b)(2)

obligations remain after the new salmon step, all D-1641 actions can be used to satisfy this obligation, even if they are designed primarily to protect the interest of consumptive water users. As in the case of the new salmon step, D-1641 actions will be implemented sequentially, although in this step, D-1641 actions will continue even after (b)(2) obligations are retired.

If additional (b)(2) obligations remain at the end of the D-1641 step, then a revised (b)(2) step will be implemented. This step will sequentially implement the December-January export reductions, the February-March export reductions, and the May export limit actions described in Table 21, as needed until the (b)(2) obligation for the year is retired. If (b)(2) obligations remain following this step, they will be forgiven.

While there will be surely be discussion of the legal underpinning of this alternative formulation of the (b)(2) accounting logic, we do not feel that the assignment of first priority to Delta water quality objectives relative to (b)(2) obligations complies with the intend of CVPIA or court findings. The following steps are needed to implement this aspect of the compliance work plan.

***Activity 1: Create and implement the new salmon CalSim-II step.***
This step will involve adding a new step that sequentially implements the AFRP, VAMP export reductions, and June actions up to the limit of the (b)(2) account that will evolve over the course of the water year according to the forecast based water year indices. Stability releases and Trinity transfers to avoid spills will not be charges against (b)(2) in this step.

***Activity 2: Implement conditional logic to govern the implementation of the final revised (b)(2) CalSim-II step.***
Under the proposed CalSim-II formulation the (b)(2) obligation may or may not be retired following the D-1641 step. CalSim-II logic must be developed to control the flow of the model depending on the status of the (b)(2) account at the end of the D-1641 step. This conditional flow is depicted in Figure 12.

INCLUDING MINIMUM INSTREAM FLOWS FOR THE SAN JOAQUIN RIVER BELOW FRIANT
The final proposed environmental compliance element is the inclusion of a minimum instream flow requirement for the San Joaquin River below Friant Dam. This is motivated by the recent ruling that called upon the Bureau of Reclamation to release sufficient water to restore the anadromous fishery in the reach between Friant and the Merced River confluence. While the ruling provided no specific guidelines as to release schedule required to satisfy this obligation, it is clear that a release regime will be a part of the environmental regulatory structure in the future and needs to be implemented in CalSim-II. The following work plan steps are needed to accomplish this goal.

***Activity 1: Define a release schedule***
As part of the failed settlement negotiations, several proposed release regimes for the lower San Joaquin River were developed. This task would involve deciding on two flow regimes from the proposed alternatives that will bracket the potential flow regime.

*Activity 2: Implement the Friant Release Logic*
Add WRESL code to CalSim-II that can read the release requirements from a look-up table.

*Activity 3: Perform Sensitivity Analysis on the two Release Regimes*
Run the model with both release regimes and assess the sensitivity of model results to the difference. If the model is highly sensitive, two baselines may be needed. If the model is insensitive, institute a compromise between the two as part of the CalSim-II baseline.

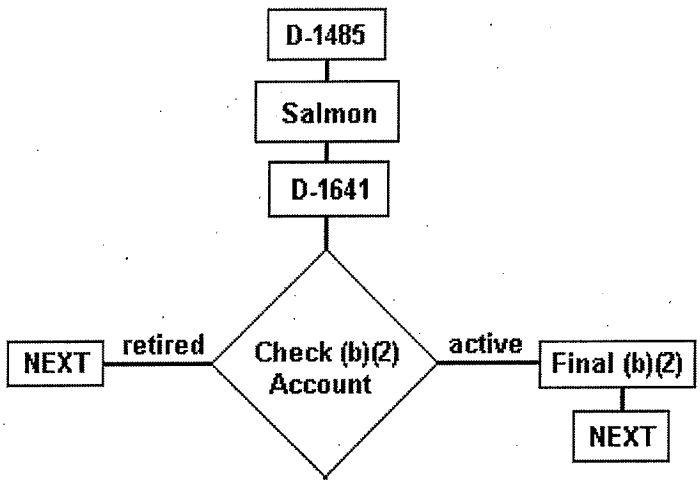


**Figure 12: Proposed CalSim-II Flow Chart**

## Environmentally Preferred CalSim-II Formulation Work Plan

As could reasonably be expected, the definition of an environmentally preferred CalSim-II formulation is a more ambitious activity than the comparison of the current model formulation against a standard of regulatory compliance. It implies that the management of California water systems will be adjusted until the point that ecosystems protected under current law are restored rather than a legalistic determination of whether or not the model accurately represents current regulations that may not be meeting restoration objectives. While the preceding discussion focusing on the full environmental compliance workplan was quite focused and detailed, the following discussion of an environmentally preferred formulation will be broader. In addition, our suggestions regarding required modifications to the CalSim-II code associated with the environmentally preferred formulation will be more strategic and less prescriptive.

With this qualification on the table, our conclusions after having completed the environmental review are that the work plan for creating a full environmental compliance formulation should focus on:

- Adapting several existing regulations to conform more with future conditions that are either anticipated or desired and would avoid the legal impacts associated with a failure to achieve real aquatic ecosystem restoration.
- Introducing operational flexibility to the CalSim-II code so that alternative sets of environmental flow regimes, beyond the establishment of minimum instream flows, can be simulated and evaluated.

In each case, several existing regulations or alternative flow regimes are presented. For each, a possible approach for CalSim-II modifications associated with the specific regulation or regime are summarized without defining a specific set of activities required to implement these modifications. These activities can be developed once an agreement has been reached to implement a specific element of the environmentally preferred formulation.

### Adapting the Representation of Existing Regulations

The following changes to specific regulations are proposed for the environmentally preferred CalSim-II formulation. As with the full compliance workplan, these items are not meant to be exhaustive as a comprehensive inventory of all existing regulations was not performed. They are representative, however, of the kind of incremental improvements in the environmental regulatory structure that may be of interest.

**Changes to the Vernalis Salinity Standard**

***Action:*** CalSim-II should be reformulated to evaluate an EC standard on the San Joaquin River at a point upstream of the Stanislaus River confluence. The contribution of a San Joaquin River fishery release schedule from Friant Dam should be considered as a source of water to help meet this standard. Doing so will dramatically reduce the amount of water that needs to be released from New Melones Dam to dilute the salt load at Vernalis, shifting responsibility for San Joaquin salinity control to all water users on the San Joaquin River.

***Possible Approach:*** This can be accomplished by reconfiguring reservoir release arcs upstream of the Stanislaus to include sub-arcs for meeting the salinity standard. CalSim-II is incapable of directly evaluating salinity as a function of flow, so this suggestion requires that new empirical relationships between flow and salinity be developed with higher spatial and temporal resolution than the flow salinity relationship now used to control the Vernalis salinity standard.

**Shift the position of X2**

***Action:*** The X2 compliance point should be moved to the western Delta when this would most benefit conditions for Delta-dependent species. Closing the Delta Cross Channel Gates as recommended in the AFRP to assist salmon smolt outmigration will affect the location of X2 and move it further to the west than would otherwise be the case. Limiting Delta export pumping when smolts are in the Delta will also result in X2 being further to the west. The combined effect of changes and Delta operations and the maintenance of X2 in the western Delta needs to be evaluated in CalSim-II.

***Possible Approach:*** Evaluate the latest scientific understanding concerning the estuarine water quality needs of key species during their various life stages in order to refine where the X2 standard should be set. Update the Kimmerer-Monismith equation and the supporting data tables to accommodate this refined understanding, including some consideration of the operation of the cross channel gates and restrictions on Delta exports. Introduce these changes into CalSim-II.

**Changes to Folsom/Nimbus Operations**

***Action:*** A portion of Folsom reservoir storage space should be held in reserve to assure adequate water supply for maintaining targeted instream flows and water temperatures for salmonid fishes at levels identified by AFRP and/or Sacramento Water Forum.

***Possible Approach:*** This can be accomplished through either the development of a dummy reservoir, or the adjustment of the "dead storage" level to absorb target storage reservations. Dead storages have very high weights, which means that the model resists releasing from the dead storage pool until the most severe conditions are encountered.

***Action:*** Increases in Sacramento Water Forum demand above current levels should have lower priority than instream flow, temperature and reservoir reserves for environmental use.

***Possible Approach:*** Incremental increases to Sacramento River withdrawals beyond the 2000 Level of Development could be performed in cycles subsequent to those considering environmental flow objectives, and be given a weight corresponding to junior water rights holders or interruptible deliveries.

***Action:*** Reduce reliance on the American River for maintaining Delta water quality standards and cap Folsom/Nimbus releases for the purpose of meeting Delta outflow requirements at 4000 cfs. This would result in greater sharing of the responsibility for meeting Delta water quality standards between all Sacramento

Valley tributaries. It may also be possible to share this responsibility with San Joaquin Valley tributaries in light of the fact that upper San Joaquin River releases will most likely occur in the future.
***Possible Approach:*** This suggestion requires the inclusion of non-CVP reservoirs (particularly Oroville) in the call for both X2 and the Water Quality standards within the ANN. The cap on reservoir releases is, however, relatively straightforward to achieve in CalSim, as it would require logic similar to the manner in which orchards downstream of New Melones are protected from high flows. Spreading responsibility for Delta water quality standards to the San Joaquin River tributaries would require the introduction of feedback between North of Delta operations and the simulated San Joaquin River Delta inflow contribution.

**Modify Delta Export Restrictions**

***Action:*** The benefits of enhanced Delta outflow, as well as more balanced Delta inflows associated with changes to Folsom/Nimbus operations, should be complemented by increased constraints on exports. During the February 1-June 15 period, exports should be capped at 35% of total inflow and/or <200% of Vernalis flow (2:1 export:Vernalis ratio).
***Possible Approach:*** The current configuration of CalSim-II could be changed to accommodate this policy suggestion without major revision.

***Action:*** VAMP (enhanced San Joaquin tributary flows + curtailed exports) should be expanded from 31 days to 61 days (April 1- May 31). The upper San Joaquin River releases should be included as a potential contribution to satisfying VAMP.
***Possible Approach:*** The current configuration of CalSim-II could be changed to accommodate this policy suggestion without major revision.

***Action:*** From October 1-Feb 29, a total of 60 days of DCC gate closures should be allowed.
***Possible Approach:*** The current configuration of CalSim could be changed to accommodate this policy suggestion without major revision.

**Refinement of the (b)(2) Accounting Rules**

***Action:*** Offset and Reset accounting rules should be used. If (b)(2) water is released from a reservoir and the reservoir subsequently fills and spills, the amount of water released from the reservoir earlier in the water year should not be charged to the (b)(2) account. If (b)(2) water is used to curtail CVP exports and the CVP responds by concurrently reducing reservoir releases that had been supporting some (or all) of the higher export rate, (b)(2) should only be charged for the difference.
***Possible Approach:*** When (b)(2) was originally implemented, the Offset/Reset accounting rules were coded into CalSim-II. Although CalSim-II has undoubtedly changed in configuration since Offset/Reset was abandoned, most of the former code should be usable in re-establishing the old accounting system in the current model.

***Action:*** The "zero credit" treatment of the (b)(2) metric should be eliminated. When the (b)(2) step produces release and export metrics are less than the D-1485 "baseline" the (b)(2) account should be credited by the amount of the difference. ***Possible Approach:*** The current configuration of CalSim-II could be changed to accommodate this policy suggestion without major revision.

ALLOWING FOR EVALUATION OF ALTERNATIVE FLOW REGIMES

As stated at the very beginning of this report, the natural flow regime that characterizes the rivers of the Central Valley has been significantly modified by the water development that has taken place over the course of the past 100 years. While fully recreating this natural hydrology is not possible given the extent to which California relies on the installed hydraulic infrastructure, it is important to explore the degree to which system operations could be modified to mimic the natural hydrology within the context of the multiple objectives to which these operations respond. Under an environmentally preferred formulation, CalSim-II would be able to contribute to this sort of evaluation. CalSim-II already is able to handle environmental constraints related to minimum flow and acceptable rates of change in stream flow. Under an environmentally preferred formulation, this functionality should be used to investigate alternative regulatory regimes, such as full implementation of the AFRP recommendations. In addition, however, CalSim-II functionality should be added to accommodate the following potential changes in the flow regime that are of interest to the environmental community.

**1. Period High Flow Events**

***Action:***

All streams should have regularly occurring high flows that help restore the riparian forest, move and sort gravel, clean out silt from deep holes in the river bed, topple trees to create large woody debris in the stream and help maintain the naturally occurring conditions that depend on periodic high water. These high flow events need to recede at a rate consistent with the needs of newly germinating plants in the riparian forest. Appropriate high flow levels and the rate at which they recede will need to be determined for each stream. Current ecological understanding suggests that such events should occur once every five to ten years.

All the streams do not need to flood in the same year, though when storm induced floods do occur, the ramping down of the high water should be done at the rate needed for new riparian seedlings to become established. When natural flooding and receding doesn't occur, it should be scheduled and the flows accounted for in the long-term operation of upstream dams. Done in a coordinated manner, these flood flow releases can arrive in the Delta to meet the needs of the export pumps. For example, while some rivers are "flooding" in one winter, other rivers could be experience "man made" drought conditions. The flows into the delta are stable but the streams are benefiting from periodic, scheduled "floods".

**2. Summer Low Flows**

***Action:***

It is not natural to have high summer flows on the Sacramento, Feather, Yuba, American and other rivers in California's Central Valley. Presently these streams run high in the summer to meet water export demands in the Delta. The preferred condition should be a changed in how water is stored and delivered to the south via the Delta so that stream flows can drop in the summer and rise in the winter.

Until the infrastructure of Delta island reservoirs, groundwater conjunctive use reservoirs or local southern California water supplies are built, the best that can be done is an adaptive management plan of rotating low flows for these different streams. Both the volume and duration of low flows need to be evaluated for invasive weed reduction and restoration benefits.

The ability to investigate these components of the flow regime will require the development of new WRESL code. The actual design of software upgrades will be developed should the proposed functionality be included in a future environmentally preferred formulation of the CalSim-II model.

## Conclusions

Having completed this environmental review of the CalSim-II model, we are left with the profound impression that it is not a tool that can – under its current formulation – fully address the legally required water management objectives. CalSim-II is, after all, a tool that has been designed to determine how best to operate the state's hydraulic infrastructure in ways that maximize the satisfaction of contractual demands. This reality is a result of both the history of water model development in California and a general analytical approach that has held sway for decades in the field of water resources planning and analysis. This approach holds that the environment is a constraint on system operations, not one of the objectives for which the system should be managed. In order to create a tool that can investigate water management innovations designed to comply with the law and restore the environment, it is not simply a matter of adjusting a few input parameters. Instead, a reformulation of the model along the lines described in this document is needed.

CalSim-II holds that the environment is a constraint on system operations, not one of the objectives for which the system should be managed. In order to create a tool that can investigate water management innovations designed to comply with the law and restore the environment, it is not simply a matter of adjusting a few input parameters.

This philosophy of including the environment as an objective in water resources management is gaining credence around the world. Unfortunately, in California we cannot get to this point if we limit ourselves to the current version of CalSim-II. On the positive side, it is clear that no one views the current version of CalSim-II as the final and definitive water planning tool. An effort is underway to develop CalSim-III, which will respond to many of the critiques that have been offered about the model in recent months and years.

The conclusions of this report are offered to constructively contribute to this evolution. We feel that they will elevate, when implemented, aquatic ecosystem restoration to a place alongside of the other water management objectives in the system as is consistent with the imperatives of law and policy. A failure to respond to these critiques would demonstrate, on the other hand, that the water management community has little interest in viewing ecosystem restoration as more that a nettlesome constraint that has to be dealt with, preferably in the most minimal fashion. This would represent a division more profound than some varying professional opinions about the best way to model a complex water resource system.

# Attachment 7

UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF CALIFORNIA

| | |
|---|---|
| NATURAL RESOURCES DEFENSE COUNCIL, et al.,<br><br>Plaintiffs,<br><br>v.<br><br>DIRK KEMPTHORNE, in his official capacity as Secretary of the Interior, et al.,<br><br>Defendants.<br><br>CALIFORNIA DEPARTMENT OF WATER RESOURCES,<br><br>Defendant-Intervenor,<br><br>STATE WATER CONTRACTORS,<br><br>Defendant-Intervenor,<br><br>SAN LUIS & DELTA-MENDOTA WATER AUTHORITY, et al.,<br><br>Defendant-Intervenors. | 1:05-cv-1207 OWW GSA<br><br>INTERIM REMEDIAL ORDER FOLLOWING SUMMARY JUDGMENT AND EVIDENTIARY HEARING |

Following the Court's May 25, 2007, Order Granting In Part and Denying In Part Plaintiffs' Motion for Summary Judgment, finding the Long-Term Central Valley Project Operations Criteria And Plan ("OCAP") Biological Opinion ("BiOp") unlawful and

inadequate, as well as the accompanying Delta Smelt Risk Assessment Matrix ("DSRAM") adopted to implement the 2005 OCAP BiOp, in violation of the Administrative Procedure Act, 5 U.S.C. § 705 et seq. (Doc. 323), a seven-day evidentiary hearing was held on August 21-24 and 29-31, 2007, to determine what interim remedies to impose. Based on the contemporaneous Findings of Fact and Conclusions of Law, after review of all the evidence, seven days of testimony, the parties' memoranda of law, and fully considering all the parties' oral arguments and proposed interim remedies, the Court enters the following:

## I. INTERIM REMEDIAL ORDER

### A. REMAND

#### 1. Completion of New Biological Opinion

The Court orders the 2005 OCAP BiOp on the effects of the coordinated Central Valley Project ("CVP") and State Water Project ("SWP") operations on the Delta smelt, REMANDED to the United States Fish & Wildlife Service ("FWS") for further consideration consistent with this Court's orders and the requirements of law. This remand shall conclude not later than September 15, 2008, at which time FWS shall issue a new Biological Opinion ("BiOp") to the U.S. Department of the Interior, U.S. Bureau of Reclamation ("Reclamation"), and the California Department of Water Resources ("DWR"), as an applicant and joint operator, on the effects of the operation of the CVP and SWP upon the Delta smelt.

#### 2. Vacatur

To avoid the potentially draconian consequences of operating the CVP and SWP without incidental take authority, this remand is made WITHOUT VACATUR. The operation of the CVP and SWP by Interior, Reclamation, and DWR, respectively, during this interim period, shall not violate the additional conditions set forth below.

B. INTERIM INJUNCTIVE RELIEF

Based on the previous findings of the imminent peril to the survival of the Delta smelt and adverse effects on its critical habitat, a preliminary injunction shall issue restraining Interior, Reclamation, and DWR, their officers, employees, agents, and all those acting in concert with them in those parties' operation of the CVP and SWP, respectively from taking any actions that are contrary to, inconsistent with, or that violate the following interim remedial measures to prevent the extinction of the Delta smelt, a threatened species, or that would destroy or adversely modify its critical habitat. This preliminary injunction shall remain in effect until the remand of and reconsultation on the BiOp is completed and a new BiOp is issued by FWS, on or before September 15, 2008, or further order of the Court, whichever shall first occur.

1. Surveys And Monitoring

a. Delta Smelt Surveys

Reclamation, DWR, and any other party shall take no action to prevent the full implementation of surveys for the Delta smelt which have been conducted by the California Department of Fish &

Game ("CDFG") including, but not limited to, the Fall Midwater Trawl ("FMWT"), Summer Townet, Spring Kodiak Trawl, and 20mm surveys.

2. Frequency of Sampling for Delta Smelt

Reclamation shall increase the frequency of sampling for Delta smelt that may be entrained at the Jones Pumping Plant to a minimum of twenty-five percent (25%) of the time, at regular intervals, whenever the Jones Pumping Plant is diverting water into the Delta-Mendota Canal.

a. Sampling Triggers

Sampling at this frequency shall commence upon either: (1) an increase in the average daily flow of the Sacramento River at Freeport to 25,000 cubic feet per second ("cfs"); or (2) when there is an increase in the average daily flow of the San Joaquin River at Vernalis by ten percent (10%) over three consecutive days after December 25; (3) survey data from the FMWT or Kodiak Survey indicate Delta smelt have moved to and are moving upstream of the confluence of the Sacramento and San Joaquin Rivers and into the Delta or January 15.

b. Larval Delta Smelt Monitoring

(1) Monitoring Triggers

Reclamation and DWR shall each monitor for the presence of larval or juvenile Delta smelt, that are less than twenty (20) millimeters (mm) in length, by Reclamation at the Jones Pumping Plant and by DWR at the Banks Pumping Plant. Such monitoring

shall occur when the pumping plants are diverting water into the Delta-Mendota Canal or the California Aqueduct, respectively. Such monitoring shall provide for sampling at least once every six (6) hours during periods in which the pumping plants are operating.

(2) Timing of Monitoring

Monitoring for the presence of larval or sub-twenty mm juvenile Delta smelt shall begin at the onset of spawning by Delta smelt as shown by: (1) the presence of spent female Delta smelt in the Spring Kodiak Trawl survey or at either export plant's salvage facility; or (2) when water temperatures in the Delta reach 12°C as determined by the average of the daily water temperatures at the Mossdale, Antioch, and Rio Vista Monitoring Stations; or (3) when larval Delta smelt are detected in the 20mm survey, whichever occurs first.

(3) Termination of Monitoring

Such monitoring shall end June 15 or a minimum of 5 consecutive days without detection of larval or juvenile Delta smelt at the CVP or SWP facilities, whichever comes last.

3. Flow Restrictions

a. Winter Pulse Flows

(1) If the triggering conditions set forth below in subparagraph I.B.3.a.(2) are met, Reclamation and DWR shall modify the operations of the CVP and SWP to achieve an average net upstream flow in Old and Middle Rivers ("OMR") not to exceed

2,000 cfs over the implementation period described in subparagraph (3).

(2) The action described in subparagraph (1) shall be initiated within three (3) calendar days after December 25 when the average daily water turbidity exceeds twelve (12) nephelometric turbidity units ("NTU") at Prisoner's Point, Holland Tract, or Victoria Canal, unless, at that time, the three-day average of flow in the Sacramento River at Freeport exceeds 80,000 cfs.

(3) This action shall end after a period of ten (10) days or when one of the following terminating conditions is met, whichever occurs first: (1) the three-day average of flow in the Sacramento River at Freeport exceeds 80,000 cfs; (2) the onset of spawning by Delta smelt occurs as shown by the presence of spent female Delta smelt in the Spring Kodiak Trawl survey or at either export plant's salvage facilities; (3) when larval Delta smelt are detected in the 20mm survey or at either export Plant's salvage facility; or when water temperature in the Delta reach 12°C determined by the average of the daily water temperatures at the Mossdale, Antioch, and Rio-Vista Monitoring stations.

b. <u>Pre-Spawning Adults</u>

(1) Reclamation and DWR shall operate the CVP and SWP to achieve a daily average net upstream (reverse) flow in the OMR not to exceed 5,000 cfs on a seven-day running average. In the event that the three-day average of flows in the Sacramento River is in excess of 80,000 cfs, when this action would otherwise commence, the action is not required to be undertaken until such

time as the three-day average of flow in the Sacramento River at Freeport falls below 80,000 cfs.

(2) This action shall commence immediately following the conclusion of the action described in subparagraph I.B.3.a., above, or on January 15, whichever is earlier.

(3) This action concludes at the onset of the spawning by Delta smelt as shown by: (1) the presence of spent female Delta smelt in the Spring Kodiak Trawl survey or at either export plant's salvage facility; (2) when larval Delta smelt are detected in the 20mm survey or at either export pumping plant's salvage facility; or (3) when water temperature in the Delta reaches 12°C determined by the average of the daily water temperatures at the Mossdale, Antioch and Rio Vista monitoring stations.

4. <u>Larval And Juvenile Delta Smelt</u>

a. Reclamation and DWR shall operate the CVP and SWP to achieve a daily average net upstream flow in OMR of between 750 and 5,000 cfs on a seven-day running average. The specific biological flow objective within this range shall be set by FWS, in consultation with Reclamation and DWR, to be determined on a weekly basis and based upon the best available scientific and commercial information concerning the distribution and status of the Delta smelt.

b. This action shall commence immediately upon the onset of spawning of Delta smelt as shown by: (1) the presence of spent female Delta smelt in the Spring Kodiak Trawl survey or at either export plant's salvage facility; (2) the larval Delta smelt are

detected in the 20mm survey or at either export plant's salvage facility; (3) when water temperature in the Delta reaches 12°C determined by the average of the daily water temperatures at the Mossdale, Antioch and Rio Vista monitoring stations.

c. This action shall continue at each facility until, when in the reasonable discretion of the Bureau, FWS, and DWR, the entrainment risk at each facility is abated, or June 20, whichever occurs first.

5. Vernalis Adaptive Management Plan

a. Reclamation and DWR shall continue to implement the Vernalis Adaptive Management Plan ("VAMP"), San Joaquin River flow enhancement and CVP and SWP export curtailment as specified under the VAMP experimental design.

b. This action shall commence on a date decided upon by the VAMP Steering Committee, but not later than May 1 and shall continue for thirty-one (31) calendar days after its initiation.

c. The requirement set forth in subparagraph I.B.4.a. shall not apply during the period in which the VAMP action is being implemented.

6. Barriers

a. Head of Old River Barrier

The installation of the spring Head of Old River Barrier by either DWR or Reclamation is prohibited until the end of VAMP action implementation.

b. Agricultural Barriers

Reclamation and DWR shall ensure that the tidal effects of the three south Delta agricultural barriers are minimized or avoided by tying open all flap gates on the barriers, from the time of their installation until the end of VAMP action implementation.

C. ADMINISTRATIVE DISCRETION

Nothing in this Order is otherwise intended to usurp or interfere with the exercise of Interior's, Reclamation's, FWS's, and DWR's discretion and expertise in their operation and management of the Projects, protection of the Delta smelt, and the implementation of the terms and conditions of this Interim Remedial Order.

It is the intent of this Interim Remedial Order that its terms and conditions be implemented to protect the interests of all parties and their constituents under the law and to achieve the minimum disruption and damage to their respective interests.

D. FEDERAL DEFENDANTS' ADDITIONAL MEASURES PENDING THE NEW BIOLOGICAL OPINION

Federal Defendants in their opening brief on injunctive relief identified measures that they committed to implement as necessary to prevent an irreversible or irretrievable commitment of resources under ESA Section 7(d) pending completion of a new Biological Opinion. [Fed. Def. Brief, Doc. 396 at pp. 19-20]. Federal Defendants committed, as of July 9, 2007, that:

a. The Bureau will not execute any long-term water service contracts with CVP contractors until the new Biological

Opinion is completed;

b. The Bureau will not implement new construction activities and long-term projects in the Delta until the new Biological Opinion is completed, including the South Delta Improvement Project, the Delta Mendota Canal/California Aqueduct Intertie Program, the Lower American River Flow Standards, and the Long Term Environmental Water Accounts;

c. The Bureau will "not increase exports from the south Delta and will operate Jones Pumping Plant within recent historical limits;" and

d. The Bureau has committed resources and staff to the continuing study of pelagic organism decline in the Delta.

These measures shall be implemented during the duration of this Order as Federal Defendants admit the measures are necessary to preserve the Delta smelt and its critical habitat.

E. PUBLIC HEALTH AND SAFETY EXCEPTION

This Interim Remedial Order shall not prevent Interior, Reclamation, or DWR from taking any action in operating the Projects that is reasonably necessary to protect human health or safety of the public, including, but not limited to, any act or omission reasonably necessary to protect the structural integrity of any CVP and SWP facility.

F. DURATION OF THIS ORDER

This Order shall take effect on the date it is filed and shall continue in effect until completion of the reconsultation on the OCAP and issuance of a new OCAP Biological Opinion, entry

of final judgment in this case, or further order of this Court; whichever first occurs.

G. STATUS REPORT

FWS shall provide the court and parties a status report on the progress of the Biological Opinion. FWS's status report shall be filed April 30, 2008.

IT IS SO ORDERED.

**Dated: December 14, 2007**

**/s/ Oliver W. Wanger**
UNITED STATES DISTRICT JUDGE

# Attachment 8

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF CALIFORNIA

| | |
|---|---|
| NATURAL RESOURCES DEFENSE COUNCIL, *et al.*,<br><br>Plaintiffs,<br><br>v.<br><br>DIRK KEMPTHORNE, in his official capacity as Secretary of the Interior, *et al.*,<br><br>Defendants,<br><br>CALIFORNIA DEPARTMENT OF WATER RESOURCES,<br><br>Defendant-Intervenor,<br><br>STATE WATER CONTRACTORS<br><br>Defendant-Intervenor,<br><br>SAN LUIS & DELTA-MENDOTA WATER AUTHORITY, *et al.*,<br><br>Defendant-Intervenors, | 1:05-CV-01207 OWW (TAG)<br><br>ORDER GRANTING IN PART AND DENYING IN PART PLAINTIFFS' MOTION FOR SUMMARY JUDGMENT (DOC. 231/232) |

## I. INTRODUCTION

This case concerns the effect on a threatened species of fish, the Delta smelt (*Hypomesus transpacificus*)[1], of the coordinated operation of the federally-managed Central Valley Project ("CVP") and the State of California's State Water Project

[1] The Delta smelt was listed as a threatened species under the ESA, March 5, 1992, 58 Fed.Reg. 12863.





("SWP"), among the world's largest water diversion projects. Both projects divert large volumes of water from the California Bay (Sacramento-San Joaquin) Delta ("Delta") and use the Delta to store water.

For over thirty years, the projects have been operated pursuant to a series of cooperation agreements. In addition, the projects are subject to ever-evolving statutory, regulatory, contractual, and judicially-imposed requirements. The Long-Term Central Valley Project and State Water Project Operations Criteria and Plan ("2004 OCAP" or "OCAP") surveys how the projects are currently managed in light of these evolving circumstances. At issue in this case is a 2005[2] biological opinion ("BiOp"), issued by the United States Fish and Wildlife Service ("FWS" or "Service") pursuant to the Endangered Species Act ("ESA"), which concludes that current project operations described in the OCAP and certain planned future actions will not jeopardize the continued existence of the Delta smelt or adversely modify its critical habitat.

The Delta smelt is a small, slender-bodied fish endemic to the Delta. Historically, Delta smelt could be found throughout the Delta. Although abundance data on the smelt indicates that the population has fluctuated wildly in the past, it is undisputed that, overall, the population has declined significantly in recent years, to its lowest reported volume in fall 2004.

[2] The biological opinion was first issued in July 2004. Then, after reconsultation, was reissued in February 2005.

In this case, Plaintiffs, a coalition of environmental and sportfishing organizations, challenge the 2005 BiOp's no jeopardy and no adverse modification findings as arbitrary, capricious, and contrary to law under the Administrative Procedure Act, 5 U.S.C. §§ 702 et seq. Before the court for decision is Plaintiffs' motion for summary judgment. Among other things, Plaintiffs allege that the BiOp fails to consider the best available science, relies upon uncertain (and allegedly inadequate) adaptive management processes to monitor and mitigate the potential impacts of the OCAP, fails to meaningfully analyze whether the 2004 OCAP will jeopardize the continued existence of the Delta smelt, fails to consider the OCAP's impact upon previously designated critical habitat, and fails to address the impacts of the entire project.

Separate opposition briefs were filed by the Federal Defendants (Doc. 242), the Department of Water Resources ("DWR") (Doc. 246), and the State Water Contractors ("SWC") (Doc. 241), along with a final brief filed collectively by San Luis & Delta-Mendota Water Authority, Westlands Water District, and the California Farm Bureau Federation ("the San Luis Parties") (Doc. 247).

## II. THE ENDANGERED SPECIES ACT

A recent Ninth Circuit opinion in *National Wildlife Federation v. National Marine Fisheries Service*, 481 F.3d 1224 (9th Cir. 2007) [hereinafter "*NWF v. NMFS*"], succinctly summarizes the relevant provisions of the ESA:

> The ESA requires federal agencies to "insure that any action authorized, funded, or carried out by such agency ... is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of [designated critical] habitat...." 15 U.S.C. § 1536(a)(2). The ESA imposes a procedural consultation duty whenever a federal action may affect an ESA-listed species. *Thomas v. Peterson*, 753 F.2d 754, 763 (9th Cir.1985). To that end, the agency planning the action, usually known as the "action agency," must consult with the consulting agency. This process is known as a "Section 7" consultation. The process is usually initiated by a formal written request by the action agency to the consulting agency. After consultation, investigation, and analysis, the consulting agency then prepares a biological opinion. *See generally Ariz. Cattle Growers' Ass'n v. U.S. Fish & Wildlife Serv.*, 273 F.3d 1229, 1239 (9th Cir.2001). In this case, the action agencies are the U.S. Army Corps of Engineers and the Bureau of Reclamation, while the consulting agency is NMFS.
>
> The consulting agency evaluates the effects of the proposed action on the survival of species and any potential destruction or adverse modification of critical habitat in a biological opinion, 16 U.S.C. § 1536(b), based on "the best scientific and commercial data available," *id.* § 1536(a)(2). The biological opinion includes a summary of the information upon which the opinion is based, a discussion of the effects of the action on listed species or critical habitat, and the consulting agency's opinion on "whether the action is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat...." 50 C.F.R. § 402.14(h)(3). In making its jeopardy determination, the consulting agency evaluates "the current status of the listed species or critical habitat," the "effects of the action," and "cumulative effects." *Id.* § 402.14(g)(2)-(3). "Effects of the action" include both direct and indirect effects of an action "that will be added to the environmental baseline." *Id.* § 402.02. The environmental baseline includes "the past and present impacts of all Federal, State or private actions and other human activities in the action area" and "the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation." *Id.* If the biological opinion concludes that jeopardy is not likely and that there will not be adverse modification of critical habitat, or that there is a "reasonable and prudent alternative[ ]" to the agency action that avoids jeopardy and adverse modification and that the incidental taking of endangered or threatened species will not violate section 7(a)(2), the consulting agency can issue an "Incidental Take Statement" which, if followed, exempts the action agency from the

> prohibition on takings found in Section 9 of the ESA. 16 U.S.C. § 1536(b)(4); *ALCOA v. BPA*, 175 F.3d 1156, 1159 (9th Cir.1999).
>
> ***
>
> The issuance of a biological opinion is considered a final agency action, and therefore subject to judicial review. *Bennett v. Spear*, 520 U.S. 154, 178, 117 S.Ct. 1154, 137 L.Ed.2d 281 (1997); *Ariz. Cattle Growers' Ass'n*, 273 F.3d at 1235.

*Id.* at *2-*3.

## III. FACTUAL BACKGROUND

For over thirty years the state and federal agencies charged with management of the CVP and SWP have operated the projects in an increasingly coordinated manner pursuant to a Coordinated Operating Agreement ("COA"). The COA, which dates to 1986, has evolved over time to reflect, among other things, changing facilities, delivery requirements, and regulatory restrictions. The most recent document surveying how the COA is implemented in light of these evolving circumstances is the 2004 Operating Criteria and Plan ("2004 OCAP" or "OCAP") issued June 30, 2004. (AR 489-728.)[3]

### A. Overview of the 2004 OCAP.

The OCAP begins with a "Purpose of Document" section which states:

> This document has been prepared to serve as a baseline description of the facilities and operating environment of the Central Valley Project (CVP) and State Water Project (SWP). The Central Valley Project - Operations and Criteria Plan (CVP-OCAP) identifies the many factors influencing the physical and institutional conditions and decision-making process under which the

[3] All "AR" references are to the administrative record provided by the U.S. Fish and Wildlife Service..





> project currently operates. Regulatory and legal instruments are explained, alternative operating models and strategies described.
>
> The immediate objective is to provide operations information for the Endangered Species Act, Section 7, consultation. The long range objective is to integrate CVP-OCAP into the proposed Central Valley document. It is envisioned that CVP-OCAP will be used as a reference by technical specialists and policymakers in and outside the Bureau of Reclamation (Reclamation) in understanding how the CVP is operated. The CVP-OCAP includes numeric and nonnumeric criteria and operating strategies. Emphasis is given to explaining the analyses used to develop typical operating plans for simulated hydrologic conditions.
>
> All divisions of CVP are covered by this document, including the Trinity River Division, Shasta and Sacramento Divisions, American River Division and Friant Division.

(AR 506.)[4]

The introductory chapter provides an overview of all of the physical components of the CVP and SWP (AR 507-520), as well as all of the relevant legal authorities affecting CVP operations (508-512).

Chapter 2, explains, among other things, that water needs assessments have been performed for each CVP water contractor, to confirm each contractor's past beneficial use in order to anticipate future demands. (AR 521.) Chapter 2 also reviews the 1986 COA and how it is implemented on a daily basis by Reclamation and DWR. (AR 523-25.) Also provided is a detailed overview of the "changes in [the] operations coordination

[4] Whether the 2004 OCAP is a "final agency action" for the purposes of the National Environmental Policy Act is at issue in a related lawsuit, *Pacific Coast Federation of Fishermen's Associations v. Gutierrez*, 1:06-cv-00245 OWW (TAG) ("*PCFFA*"). This overview of the OCAP does not prejudge the merits of the pending motion to dismiss in *PCFFA*.

environment since 1986," which include:

- Changes due to temperature control operations on the Sacramento River;
- Increases in the minimum release requirements on the Trinity River;
- Implementation of CVPIA 3406(b)(2) and Refuge Water Supply contracts;
- Commitments made by the CVP and SWP pursuant to the Bay-Delta Accord and the subsequent implementation of State Water Resources Control Board ("SWRCB") Decision-1641;
- The Monterey Agreement;
- The Operation of the North Bay Aqueduct (which was not included in the 1986 COA).
- The SWP's commitment to make up for 195,000 acre-feet of pumping lost to the CVP due to SWRCB Decision 1485;
- Implementation of the Environmental Water Account; and
- Constraints imposed by various endangered species act listings, including that of the Sacramento River Winter-Run Chinook Salmon, the Sacramento River Spring-Run Chinook Salmon, the Steelhead Trout, and the Delta Smelt (which resulted in the issuance of biological opinions in 1993, 1994, and 1995 concerning CVP/SWP operations and the South Delta Temporary Barriers Biological Opinion in 2001)

(AR 525-28.) The OCAP also reviews the regulatory standards imposed by SWRCB D-1641, which include water quality standards based on the geographic position of the 2-parts-per-thousand





isohale (otherwise known as "X2"), a Delta export restriction standard known as the export/inflow (E/I) ratio, minimum Delta outflow requirements, and Sacramento River and San Joaquin River flow standards. (AR 530-537.) In addition to imposing requirements, D-1641 granted the Bureau and DWR permission to use each project's capabilities in a coordinated manner. (AR 537-38.)

This is not a complete overview of the projects' operations covered in the OCAP. Numerous regulatory and operational changes have taken place in recent years. As the OCAP's "Purpose of Document" section explains, the immediate objective of the OCAP is to lay out all such regulatory and other operational information so that ESA Section 7 consultation can proceed to evaluate how project operations will effect the Delta smelt under various projected future conditions.

B. **Applying the ESA to Project Operations**.

Because endangered and/or threatened species, including the Delta smelt, reside in the area affected by the CVP and SWP, the 2004 OCAP, administered on behalf of the federal government by the Bureau of Reclamation ("Bureau"), must comply with various provisions of the ESA. Specifically, prior to authorizing, funding, or carrying out any action, the acting federal agency (in this case, the Bureau) must first consult with FWS and/or NMFS to "insure that [the] action...is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined...to be critical...." 16 U.S.C. § 1536(a)(2) [ESA § 7(a)(2)]. This form of

consultation is called "formal consultation," and concludes with the issuance of a biological opinion. 50 C.F.R. § 402.02.

Alternatively, under certain circumstances, a federal agency may pursue "early consultation," on behalf of an agency or private party (referred to as a "prospective applicant") who will require formal approval or authorization to undertake a project. *Id.* Early consultation may be requested when the prospective applicant "has reason to believe that an endangered species or a threatened species may be present in the area affected by this project and that implementation of such action will likely affect such species." 50 C.F.R. § 402.11(b). The result of early consultation is a "preliminary biological opinion," the contents of which are "the same as for a biological opinion issued after formal consultation except that the incidental take statement provided with a preliminary biological opinion does not constitute authority to take listed species." § 402.11(e). Subsequently, the preliminary biological opinion may be "confirmed" after the prospective applicant applies to the federal agency for a permit or licence. Once a request for confirmation is received, the FWS must either confirm that the preliminary biological opinion stands as the final biological opinion or must request that the federal agency initiate formal consultation. § 402.11(f).

In this case, the 2004 OCAP BiOp[5] contemplates increases in

[5] The OCAP itself does not plan for increased pumping or the construction or operation of any new facilities, nor does it describe or model flow regimes under any of these future plans. These planned operational changes are set forth in the BA and the BiOp. (*See* AR 381-423 (describing the effects of those actions





water diversions and the construction of new facilities in the Delta. (AR 256-271.) The maximum daily diversion rate in Clifton Court Forebay will increase from 6,680 cubic feet per second (CFS) to 8,500 CFS (27% increase in pumping) and eventually to 10,300 CFS (54% increase). Permanent barriers within the south Delta will be constructed and operated. An intertie between the California Aqueduct and the Delta-Mendota Canal will be constructed and operated. Water deliveries from the American River will be doubled. New deliveries of CVP water to the Freeport Regional Water Project will be made. Water transfers resulting in an annual 200,000 to 600,000 acre-feet increase in Delta exports will result. (AR 256, 339-40, 357-59, 371, 382-83, 465.)

The Bureau submitted some of these operational changes for formal consultation with FWS concerning their impact on the Delta smelt, while other changes were subject only to early consultation:

> This biological opinion covers formal and early consultation for the operations of the CVP and SWP. The formal consultation effects described in this biological opinion cover the proposed 2020 operations of the CVP including the Trinity River Mainstem ROD (Trinity ROD) flows on the Trinity River, the increased

included in formal consultation, including re-operation of the Trinity River, increased demands on the American River, operation of the Freeport Regional Water Project ("FRWP"), and operation of an intertie between the Delta-Mendota Canal and the California Aqueduct); AR 357-61 (describing the "items for early consultation," including operation of components of the South Delta Improvement Project, which calls for pumping at Banks to increase to 8500 cfs, operation of permanent barriers in various places within the Delta, the operation of a long term EWA, the use of CVP/SWP capacity to facilitate expanded water transfers, and further integration of CVP/SWP operations.)

> water demands on the American River, the delivery of CVP water to the proposed Freeport Regional Water Project (FRWP), water transfers, the long term Environmental Water Account (EWA), the operation of the Tracy Fish Facility, and the operation of the SWP-CVP intertie. The effects of operations of the SWP are also included in this opinion and include the operations of the North Bay Aqueduct, the Suisun Marsh Salinity Control Gates, the Skinner Fish Facility and water transfers.
>
> Early consultation effects include the effects of operations of components of the South Delta Improvement Program (SDIP). These operations include pumping of 8500 cubic feet per second (cfs) at the SWP and Banks Pumping Plant (hereafter referred to as 8500 Banks), permanent barrier operations in the South Delta, the long term EWA, water transfers, and CVP and SWP operational integration. There are two separate effects sections in this biological opinion, one for Formal Consultation and one for Early Consultation. In addition, there is an incidental take for formal consultation and a preliminary incidental take for early consultation.

(AR 2, 248.)[6]

C. History of This Lawsuit.

On July 30, 2004, FWS issued a Biological Opinion (the "2004 OCAP BiOp"), addressing both formal and early consultation for the above-described OCAP actions. (AR 1.)[7]

On August 4, 2004, the Ninth Circuit decided *Gifford Pinchot*

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[6] The first step in the consultation process is usually the preparation of a Biological Assessment ("BA") by the action agency (in this case, the Bureau), the purpose of which is to "evaluate the potential effects of the action on listed [] species and designated [] critical habitat and determine whether any such species or habitat are likely to be adversely affected by the action...." 50 C.F.R. § 402.12(a). In this case, the Bureau issued its BA regarding the "Long-Term Central Valley Project and State Water Project Operations and Criteria Plan" on June 30, 2004. (AR 729.) The BA describes the project on which consultation is being held, both early and formal, in much the same terms as are used in the BiOp.

[7] Prior to 2004, the OCAP operated under Biological Opinions issued in 1993 and 1995.





*Task Force v. United States Fish & Wildlife Serv.*, 378 F.3d 1059, 1069 (9th Cir. 2004), which held that the FWS's definition of "adverse modification" to critical habitat is an impermissible interpretation of the ESA because it focuses on whether critical habitat modifications would impact the survival of a species, effectively ignoring the statutorily-mandated goal of "recovery." On November 4, 2004, in response to this ruling, the Bureau requested reinitiation of consultation to address critical habitat issues.

Plaintiffs in this case, a coalition of non-profit conservation organizations, filed suit on February 15, 2005, alleging that the 2004 OCAP BiOp was legally inadequate in light of *Gifford Pinchot* and should be invalidated. (Doc. 1.) Plaintiffs named as defendants the Department of the Interior and the FWS. (*Id.*)

On February 16, 2005, FWS issued an amended BiOp (the "2005 OCAP BiOp," "OCAP BiOp," or "BiOp"), which superceded the 2004 OCAP BiOp. (AR 247.) The 2005 OCAP BiOp concludes that the coordinated operation of the SWP and CVP, including the proposed future actions, will not jeopardize the Delta smelt's continued existence. (AR at 469.) Although the BiOp recognizes that existing protective measures may be inadequate, the FWS concluded that certain proposed protective measures, including the EWA and a proposed "adaptive management" protocol would provide adequate protection. (*Id.*)

Since the filing of this complaint, Federal Defendants have reinitiated § 7 consultation and contend this case should be dismissed as moot, or stayed for a voluntary remand of the 2005

BiOp without vacatur.

Plaintiffs filed a supplemental complaint on May 20, 2005, challenging the amended BiOp on various grounds. (Doc. 128 pt. 8.)

D. **Delta Smelt Abundance**.

Smelt once were one of the most common pelagic[8] fish in the Delta, having previously occupied the waters from "Suisun Bay and Montezuma Slough, upstream to at least Verona on the Sacramento River, and Mossdale on the San Joaquin River." (AR 365.) Smelt abundance has "declined irregularly" for at least the past 20 years. (AR 365-67.) FWS relies primarily upon two indices to monitor Delta smelt abundance, calculated from the Summer Tow Net Survey ("TNS") and the Fall Midwater Trawl ("FMWT"). (AR 366-67, 1022.) The TNS index, which measures the abundance and distribution of juvenile Delta smelt, constitutes "one of the more representative indices because the data have been collected over a wide geographic area (from San Pablo Bay upstream through most of the Delta) for the longest period of time (since 1959)." (AR 370.) Since 1983, except for three years (1986, 1993, and 1994), the TNS has remained consistently lower than ever previously recorded. (*Id.*)

The FMWT index, which measures the abundance and distribution of late juveniles and adult Delta smelt from San Pablo Bay to Rio Vista on the Sacramento River and Stockton on the San Joaquin River, is the second longest running survey

[8] Pelagic fish live in open water, generally away from vegetation or the bottom. (AR 365.) A significant amount of the smelt's habitat are the Delta waters and waters of surrounding areas.





(since 1967). The BiOp reviewed the FMWT trends as follows:

> Although this index has fluctuated widely (AR 9201-02, 9222), it has "declined irregularly over the past 20 years." (AR 370-71.) Since 1983, the FMWT has registered more low indices for more consecutive years than previously recorded. Until recently, except for 1991, this index has declined irregularly over the past 20 years. Since 1983, the delta smelt population has exhibited more low fall midwater trawl abundance indices, for more consecutive years, than previously recorded. The 1994 FMWT index of 101.7 is a continuation of this trend. This occurred despite the high 1994 summer townet index for reasons unknown. The 1995 summer townet was a low index value of 319 but resulted in a high FMWT index of 898.7 reflecting the benefits of large transport and habitat maintenance flows with the Bay-Delta Accord in place and a wet year. The abundance index of 128.3 for 1996 represented the fourth lowest on record. The abundance index of 305.6 for 1997 demonstrated that the relative abundance of delta smelt almost tripled over last years results, and delta smelt abundance continued to rise, peaking in 1999 to an abundance index of 863, only to fall back down to the low abundance indexes of 139 for 2002 and 213 for 2003.

(AR at 371.)

The 2004 FMWT index, which was not discussed in the BiOp, was calculated to be 74, the lowest ever recorded. (AR 9202.) (This omission forms the basis of one of Plaintiffs' challenges to the BiOp.) The survey was apparently released in December 2004, and was specifically cited to FWS in February 2005.

At the hearing on the summary judgment motions, Federal Defendants in substance argued that despite years of study, the abundance data for the annual Delta smelt population is fraught with uncertainties and "not enough is known about the species" to accurately and finitely measure with certainty the project's effects on Delta smelt. FWS maintains the one to two year life expectancy of the smelt also contribute to this lack of certainty.

E. **Relationship Between Abundance and Project Operations.**

The BiOp cites several reasons for the smelt's decline. First, since the mid 1800s, mining, agricultural use, and levee construction caused the loss of a large portion of smelt habitat. (AR at 365.) Second, recreational boating in the Delta has resulted in the presence and propagation of "predatory non-native fish" and an increase in the rate of smelt erosion resulting from boat wakes. (*Id.*) Third, reduced water quality "from agricultural runoff, effluent discharge and boat effluent has the potential to harm the pelagic larvae and reduce the availability of the planctonic food source." (*Id.* at 366.) Finally, the BiOp acknowledges that "delta smelt have been increasingly subject to entrainment, upstream or reverse flows of waters in the Delta and San Joaquin River, and constriction of low salinity habitat to deep-water river channels of the interior Delta." (*Id.*) The BiOp acknowledges that these final adverse effects are "primarily a result of the steadily increasing proportion of river flow being diverted from the Delta by the Projects, and occasional droughts." (*Id.* (emphasis added).) The BiOp in no way quantifies the contribution of each of these factors to the smelt's decline. The parties dispute the extent to which project operations jeopardize the smelt.

F. **Relationship Between Smelt and "X2."**

Smelt are euryhaline (tolerant of a wide range of salinities), but generally occur in water with less than 10-12 parts per thousand (ppt) salinity. (AR at 362.) For a large part of its life span, Delta smelt are thought to be associated with the "freshwater edge of the mixing zone," where the salinity





is approximately 2 parts per thousand (often referred to as "X2"). (AR at 366.) The summer TNS index increases dramatically whenever X2 is located between Chipps and Roe islands. (*Id.*) Whenever the location of X2 shifts upstream of the confluence of the Sacramento and San Joaquin, either as a result of water diversions or natural conditions, smelt abundance decreases. (*Id.* at 371.)

G. **The Concept of "Salvage."**

The BiOp's "no jeopardy" conclusion relies on the concept of "salvage," which refers generally to the process of using mechanical devices to screen fish that would otherwise be entrained in project facilities (e.g., pumps) into holding tanks for transport to other parts of the Delta. (*See e.g.*, AR 321.) Unlike many other fish species in the Delta, Delta smelt do not survive the salvage process, "either due to stress and injury from handling, trucking and release, or from predation in or near the salvage facilities, the release sites, or in Clifton Court Forebay." (AR at 413.) As a result, for Delta smelt, FWS uses the terms salvage and entrainment essentially interchangeably. (*See id.* ("To simplify predictions of the difference in salvage (and by extension entrainment) between model scenarios....")[9]

Previous BiOps regarding CVP and SWP operations used salvage to set take limits. For example, the 1995 BiOp's incidental take statement set take exceedence levels for Delta smelt based on "[m]onthly average delta smelt salvage at the Federal and State

[9] The BiOp contradictorily acknowledges that "although salvage is used to index delta smelt take, it does not reliably index delta smelt entrainment." (AR 419.)

Fish Facilities from 1980 to 1992 by water year type." (AR at 11765.) Essentially, take limits were set according to how much salvage had occurred in the past.

More recently, project managers, fisheries officials, and other experts came to the consensus that the salvage approach was insufficient on its own. For example, one DWR biologist noted that the singular focus on historic salvage had problems:

> Higher levels of take are allowed in below normal years merely because this is what the projects "took" historically. However, the population is more condensed in below normal years and possibly more vulnerable to entrainment.

(AR 5532.) Experts advocated (a) further research into the relationship between the position of the Delta smelt and environmental conditions (AR 4881); and (b) the adoption of a flexible management approach, which would allow new information to be "folded back into the operation and conservation strategies." (AR 4870.) The result was a "layered" approach to managing the smelt, made up of more protective take limits than previously imposed along with the implementation of an adaptive management protocol.

I. **Revised Take Exceedence Levels Used In the BiOp**.

The BiOp includes "hard" take limits,[10] based on historic "salvage density estimates," adjusted to account for operational constraints under the 2004 OCAP and presumed increased environmental water flows. Separate take limits were established for formal and early consultation purposes.

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[10] These "hard" take limits, as the Defendants and Defendant Intervenors referred to them during oral argument are different from a separate take trigger that is part of the DSRAM process described below.





The revision of the take limits began with historic catch data from periodic samples of salvaged fish. (*See* AR 413.) Data about the volume of water diverted during the collection period is then used to estimate the fish per volume of water diverted. This is referred to as the "salvage density."[11] (*Id.*) Historically, salvage density varied greatly depending on whether the year was wet (above normal), dry (below normal, dry, or critical) year. Wet and dry year data were analyzed separately. (*Id.*) The estimates were then inputted into a computer modeling system, CALSIM II, to estimate take under varying assumptions about future project operations, including programs designed to improve environmental conditions, such as the Environmental Water Account. (AR 413-14.)

Several different scenarios or "Studies" were run through CALSIM II and included in the BiOp. For example, Study No. 1 reflects the 1995 regulatory base case, without any changes in project operations and without the addition of any environmental water programs. Study No. 4a estimates a take level for flow conditions planned under the operations subject to final consultation (changes to flows in the Trinity River, future development levels, and the operation of the Freeport Regional Water Project and the Intertie). Study 4a included flow adjustments required by D-1641 and VAMP, along with projected CVPIA (b)(2) flows, but did not include operation of the EWA.

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[11] DWR insisted during oral argument that the data used to run the CALSIM II models was not "salvage" data but was rather "density data." The BiOp is explicit that the models were run using a "salvage density" estimate generated from periodic samplings of salvaged fish.

Study No. 5a was similar to 4a, except that it added projected EWA flows. Separately, in Study No. 5, CALSIM II simulated flow modifications projected to occur as a result of "those projects subject to early consultation," specifically the increased pumping and permanent barriers called for in the planned South Delta Improvement Project ("SDIP"). (AR 374, 414-19; Sommer Decl. ¶5.) Each modeling scenario was run separately for various water year types (Wet, Above Normal, Below Normal, Dry, and Critically Dry) and independently estimated take at CVP and SWP facilities.

The BiOp based its conclusions for formal consultation on the results of the Study No. 5a, and for early consultation on the results of Study No. 5. The results of the modeling scenarios for Study No. 5a are set forth in several tables at pages 414 through 419 of the AR. The following table summarizes the changes in estimated take for Study No. 5a, for each type of water year, relative to the 1995 base case. In other words, the positive figures represent the number of additional smelt that will be taken per month under formal consultation relative to the 1995 base case (Study No. 1) while negative numbers represent how many fewer smelt will be taken per month relative to the 1995 base case.[12]

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[12] The information contained in these tables was derived by the court from the BiOp but was not presented in this form in the BiOp.





**Table 1:**
**Summary of Results for CVP Salvage Under Study No. 5a**

| Month | Wet Year | Above Normal Year | Below Normal Year | Dry Year | Critically Dry Year |
|---|---|---|---|---|---|
| Adults | | | | | |
| December | -1 | -1 | -3 | -3 | -41 |
| January | -13 | -13 | -12 | -10 | -98 |
| February | -33 | -36 | +63 | -60 | +9 |
| March | +29 | -40 | -83 | -19 | +1 |
| Largely Juveniles | | | | | |
| April | 0 | 0 | -16 | +5 | 0 |
| May | 0 | 0 | -9017 | -14469 | -11652 |
| June | 0 | 0 | 0 | -2910 | 0 |
| July | 0 | +11 | +7 | -74 | 0 |
| Net: December-March | -17 | -89 | -35 | +28 | -130 |
| Net: April-July | 0 | +11 | -9025 | -17448 | -11652 |

**Table 2:**
**Summary of Results for SWP Salvage Under Study No. 5a**

| Month | Wet Year | Above Normal Year | Below Normal Year | Dry Year | Critically Dry Year |
|---|---|---|---|---|---|
| Adults | | | | | |
| December | -6 | -6 | -16 | -15 | -11 |
| January | -76 | -87 | -82 | -87 | -104 |
| February | +86 | -94 | 0 | 0 | +51 |
| March | +98 | +91 | +63 | 0 | +2 |
| Largely Juveniles | | | | | |
| April | -60 | -77 | -365 | -144 | 0 |
| May | -27188 | -25933 | -31122 | -32083 | -7269 |
| June | -1096 | -129 | -53 | .1267 | 0 |
| July | 0 | +282 | +318 | +493 | +175 |
| Net: December-March | +102 | -95 | -35 | -102 | -62 |
| Net: April-July | -28346 | -25857 | -31213 | -33000 | -7095 |

For the CVP, CALSIM II predicts significant reductions in smelt salvage during the months of December through July in below normal and dry years, when compared to the regulatory base

case.[13] However, under certain scenarios, CVP salvage increases during other months of the year relative to the regulatory base case, because pumping is predicted to increase during these months to make up for water released from storage for fish protection purposes. For the SWP, salvage stays relatively level for the months of December through March. However, salvage decreases for the months of April through July relative to the regulatory base case.

Based on CALSIM II Study 5a, FWS calculated the amount of "combined salvage" (i.e., for both projects) estimated under the formal consultation scenario, for each month, according to water year type. The BiOp rounded the numbers up to the nearest 100 and used those figures to set incidental take limits by water year type. (AR 471-472.)

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[13] The tables at pages 414 and 419 of the AR do not list the absolute number of smelt estimated to be taken in any given month under the 1995 regulatory base case (Study No. 1). However, the incidental take limits (set forth in the Table 3 below) were based on the absolute numbers of smelt that are projected to be taken under Study No. 5a. For example, the take limit for the month of May in a Critically Dry year, set at 30,500, under the CALSIM II results in a reduction of the 30,500 to 18,921 (representing 11,652 reduction in CVP salvage plus 7,269 reduction in SWP salvage) lower than the 1995 regulatory base case.





**Table 3:**
**Incidental Take Limits by Water Year Type**
**(For Both CVP and SWP)**

| | Water Year Type | | |
|---|---|---|---|
| | Month | Wet or Above Normal | Below Normal, Dry, or Critical |
| Monthly Incidental Take | October | 100 | 100 |
| | November | 100 | 100 |
| | December | 700 | 400 |
| | January | 3000 | 1900 |
| | February | 2300 | 1700 |
| | March | 1300 | 1300 |
| | April | 1000 | 1100 |
| | May | 37800 | 30500 |
| | June | 45300 | 31700 |
| | July | 3500 | 2500 |
| | August | 100 | 100 |
| | September | 100 | 100 |

Because these incidental take levels are based on predictions produced by CALSIM II Study 5a, they do not assume any smelt protection actions under the DSRAM, but do assume continued availability of the EWA water. (AR 374, 471.)

FWS determined that the level of anticipated take "is not likely to result in jeopardy to the smelt because this level of take is at or below historical levels of take." (AR 474.)

However, the BiOp also acknowledges that "the operations of the Projects under formal consultation as described in the Project Description will result in adverse effects to delta smelt through entrainment at the CVP and SWP and by drawing delta smelt into poorer quality habitat in the south delta." (AR 422 (emphasis added).) The BiOp concludes that "with the inclusion of [certain] conservation measures described [in the BiOp] and the implementation of the [Delta Smelt Risk Assessment Matrix], these adverse effects would be avoided or minimized." (*Id.*

(emphasis added).) "[W]ith these conservation measures in place, the re-operation of the Trinity River, the increased level of development on the American River, the Freeport Diversion, the Suisun Marsh Salinity Control Gates, the Barker Slough Diversion, or due to changes to X2...are not expected to result in adverse effects to delta smelt." (AR 423.)

FWS' conclusions admit project operations will result in adverse effects to delta smelt, which are unquantified, and can only be avoided by conservation measures and implementation of the DSRAM.

H. "**Conservation Measures**."

The "conservation measures" contemplated are listed in the Summary of Effects section of the BiOp and include: (1) the Environmental Water Account ("EWA"); (2) Central Valley Project Improvement Act (b)(2) water; (3) State Water Resource Control Board's Water Rights Decision 1641; (4) the Vernalis Adaptive Management Plan ("VAMP"); and (5) the DSRAM adaptive management plan. (AR 466-68.)

**1. CVPIA(b)(2) Water.**

According to the 1992 Central Valley Project Improvement Act, the CVP must "dedicate and manage annually 800,000 acre-feet of Central Valley Project yield for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by this title; to assist the State of California in its efforts to protect the waters of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary; and to help to meet such obligations as may be legally imposed upon the





Central Valley Project under State or Federal law following the date of enactment of this title, including but not limited to additional obligations under the Federal Endangered Species Act." Title XXXXIV of the Reclamation Projects Authorization and Adjustment Act of 1992, Pub. L. 102-575, 106 Stat. 4600, 4706 (1992). (*See* AR 372.)

FWS, in consultation with the Bureau and other agencies, may use this "(b)(2) water" to meet Water Quality Control Plan (WQCP) obligations and any other requirements imposed by law after 1992. "For example, (b)(2) water has been used to maintain flows on Clear Creek to provide adequate spawning and rearing habitat for Chinook salmon. Water exports at the CVP have also been reduced using (b)(2) water to reduce entrainment of salmon or delta smelt at the salvage facilities. This ongoing action provides a benefit to delta smelt in most years." (AR 372.)

The base CVP yield committed to fish restoration is fixed by statute and is mandatory. This fixed supply is subject to reduction up to 25% in critically dry years under CVPIA § 3406(b)(2)(C).

**2. Environmental Water Account.**

The Environmental Water Account ("EWA") is "an adaptive management tool that aims to protect both fish and water users as it modifies water project operations in the Bay-Delta." (AR 373.)

> The EWA provides water for the protection and recovery of fish beyond that which would be available through the existing baseline of regulatory protection related to project operations. The EWA buys water from willing sellers or diverts surplus water when safe for fish,

> then banks, stores, transfers and releases it as needed to protect fish and compensate water users for deferred diversions.

(*Id.*)

The EWA has been used to benefit smelt by allowing for the curtailment of project export pumping during critical time periods. (*Id.*) The EWA could also be used to increase in-stream flows or increase outflows in the Delta, both of which would benefit the smelt. (*Id.*) The EWA is not fixed by statute nor is annual funding assured, and the water supply it provides, though reasonably anticipated, is not immutable.

**3. Water Rights Decision 1641.**

State Water Resource Control Board Decision 1641 (D-1641) imposes certain minimum flow and water quality objectives upon the projects:

> D-1641 includes specific outflow requirements throughout the year, specific export restraints in the spring, and export limits based on a percentage of estuary inflow throughout the year. D-1641 obligates the SWP and CVP to comply with the objectives in the 1995 Bay-Delta Plan. The Service issued a biological opinion on the Bay-Delta plan to the Environmental Protection Agency on November 2, 1994. The water quality objectives in the 1995 Bay-Delta Plan and in D-1641 are designed to protect in-Delta agricultural, municipal and industrial, and fishery uses and vary throughout the year and by water year type.... D-1641 will also protect delta smelt by providing transport, habitat and attraction flows.

(AR 373 (citations omitted).)

The D-1641 requirements are mandatory under the projects' operating permits. The water to satisfy D-1641 comes from 3406(b)(2) yield and supplemental sources the Bureau utilizes.





**4. Vernalis Adaptive Management Plan (VAMP).**

The Vernalis Adaptive Management Plan (VAMP) is an experimental program that had its origin in D-1641. (AR 373.) It provides for flows on the lower San Joaquin River and export curtailments at the projects. (*Id.*) VAMP's purpose is to "provide pulse flows on the San Joaquin River and improve habitat conditions in the Delta by reducing exports at the CVP and SWP" over a 31 day period in April and May for the benefit of Chinook salmon and Delta smelt. (*Id.*) Currently, water used to reduce exports at the CVP under VAMP is accounted for as CVPIA (b)(2) water. (*Id.*) If export reductions are taken, the EWA is used to supply contractors to make up for the transfers. VAMP flows "allow larval and juvenile smelt to avoid becoming entrained at the export facilities and to move downstream to Suisun Bay." (*Id.*)

The VAMP water supply is not irrevocably fixed or assured.

**I. <u>Delta Smelt Risk Assessment Matrix (DSRAM)</u>.**

The BiOp's other, primary protection for the smelt is the implementation of a new adaptive management protocol, known as the Delta Smelt Risk Assessment Matrix ("DSRAM"). The DSRAM utilizes a list of trigger criteria to precipitate responses. (AR at 344.) The criteria are:

(1) the previous year's FMWT index;

(2) the risk of smelt entrainment based upon the location of X2;

(3) the estimated duration of the smelt spawning period,

based on water temperature;

(4) the presence of spawning female smelt;

(5) the proximity of the smelt to project pumping facilities; and

(6) a salvage trigger for adult and juvenile smelt. (AR 346.)

**1. The DSRAM Process.**

If any trigger criteria is met or exceeded, a Delta Smelt Working Group ("DSWG") is convened. The DSWG consists of representatives from FWS, the California Department of Fish and Game, DWR, the United States Environmental Protection Agency, the Bureau, and the California Bay-Delta Authority. (*See* AR 344-45.) The DSWG then recommends corrective actions to a Water Operations Management Team ("WOMT"). (*Id.*) The OCAP BiOp identifies four specific actions that the DSWG and WOMT must consider taking if one or more trigger criteria occur: (1) export reductions at one or both of the projects; (2) changes in the south Delta barrier operations; (3) changes in San Joaquin River flows; and (4) changes in the operation of the Delta cross channel.[14] The DSRAM does not contain defined action criteria, but instead leaves any response wholly to the discretion of the two groups who administer the DSRAM (DSWG and WOMT).

**2. DSRAM Implementation.**

The BiOp acknowledges although FWS is "confident that use of

[14] The DSRAM also includes a chart illustrating when during the year each of these actions will be available. (AR 346.)





the DSRAM will reduce the frequency with which actual salvage exceeds the median predicted salvage, the exceedence frequency could be as high as 50%." (AR 471.) There is no analysis of the duration or consequences from such exceedence. The DSRAM provides no operating criteria or action schedule, specifying when mitigation actions must be taken. It is not possible to predict what, how and when DSRAM measures will be implemented.

**J. Recent Experience with DSRAM.**

DWR offered post-record evidence regarding the manner in which DSRAM has actually been implemented since its inception. This post-record activity could not have been considered by the agency. A motion to strike the proffered evidence was sustained. The offer of proof includes two "fish actions" that were taken in 2005 in response to "triggers" and a third that was planned but avoided when project water increased in early 2006, a wet year. DWR's offer of proof is to show positive experience in operation of the DSRAM.

**K. Recent Procedural History.**

The Federal Defendants acknowledge that "[s]hortly before the 2005 OCAP BiOP was completed, a fall midwater trawl survey of delta smelt revealed a substantial decline in the population index for the species" to the lowest ever. (Doc. 242-1, at 4.) The Federal Defendants do not concede that the existence of this data renders the BiOp arbitrary and capricious, because "limited analysis of this data existed, and the Service relied on the raw data, and its own professional judgments as the best available scientific and commercial data available." (*Id.*) Nevertheless,

"the CALFED agencies have continued to assemble and analyze new data and information." (*Id.*) For example, scientists from CALFED agencies "recently" developed a document based upon the new data: the Interagency Ecological Program Synthesis of 2005 Work to Evaluate the Pelagic Organism Decline (POD) in the Upper San Francisco Estuary (the "IEP POD Synthesis"). This document led the Federal Defendants to conclude that the OCAP for the CVP and SWP may affect Delta smelt in a manner or to an extent not previously considered. (IEP POD Synthesis, Doc. 240, Attachment 1.)

On July 6, 2006, the Bureau requested that the FWS re-initiate consultation concerning the impact of the OCAP on the Delta smelt. (Doc. 240.) In a July 6, 2006 letter to the FWS, the Bureau acknowledged that "emerging data indicates an apparent substantial decline in the Delta smelt population index." (Doc. 240-2.)

1. **No Dismissal or Stay**.

In light of the second re-initiation of consultation, federal defendants sought dismissal on prudential mootness grounds, a voluntarily remand without vacatur, or a stay pending the completion of reconsultation. (*See* Docs. 242-1, 273.) The motion for stay was joined by the DWR (Doc. 277), and various Defendant-Intervenors (Doc. 274). Plaintiffs opposed because Federal Defendants refused to withdraw the challenged BiOp and stated their intent to continue CVP and SWP operations under the disputed BiOp and its incidental take statements during the time period necessary to complete re-consultation, now projected to be





July 2008, more than two and one-half water years following the effective date of the disputed BiOp. (*See* Doc. 279.)

Defendants' motion to dismiss on prudential mootness grounds was denied:

> Plaintiffs' concerns have not been fully addressed by the reinitation of consultation. Federal Defendants are relying in part on the challenged BiOps in operating the CVP and intend to continue to do so. The controversy over whether the BiOps and OCAP should have continued viability is real and substantial. and this court could provide relief, in the form of a decision invalidating the BiOps followed by hearings on interim remedies. Under these circumstances, it is not appropriate to deem this case prudentially moot.

(Doc. 301 at 18 (footnotes omitted).)

The motion for voluntary remand without vacatur was denied based on the general standard for vacatur set forth in *Natural Resources Defense Council v. U.S. Dept. of the Interior*, 275 F. Supp. 2d 1136, 1143 (C.D. Cal. 2002), which considers "the seriousness of the order's deficiencies" and "the disruptive consequences of an interim change that may itself be changed." No evidence or argument was presented regarding the nature of the prejudice that might result from invalidating the BiOp (*id.* at 20), and numerous factual and legal disputes exist regarding the seriousness of the order's deficiencies (*see id.* at 27). The court was left to speculate what consequences to the species would result if injunctive relief were ordered against continued implementation of the disputed BiOp.

The stay motion, based on the primary jurisdiction doctrine, was denied on the authority of *Lockyer v. Mirant Corp.*, 398 F.3d 1098, 1109 (9th Cir. 2005)(a party seeking a stay "must make out a clear case of hardship or inequity in being required to go

forward, if there is even a fair possibility that the stay for which he prays will work damage to someone else."). The order held: "Plaintiffs are entitled to have their complaint decided on the merits, particularly given the fact that Defendants continue to rely on the challenged BiOps as if they were lawfully enacted." (Doc. 301 at 33.) The apparent increasing jeopardy to the smelt by and after February of 2005 militates against further delay while FWS continue "to study" the issue of jeopardy, an exercise that has continued for almost a decade.

## IV. POST-RECORD EVIDENTIARY DISPUTES

### A. Objections to Declaration of Ted Sommer.

DWR offers the post-record declaration of Ted Sommer, Ph.D, to explain (1) the concept of salvage and its relationship to the take exceedence levels in the BiOp; (2) the operation of DSRAM; (3) and the manner in which DSRAM has been implemented since its inception.

Generally, "the focal point for judicial review should be the administrative record already in existence, not some new record made initially in the reviewing court." *Camp v. Pitts*, 411 U.S. 138, 142 (1973). However, the Ninth Circuit recognizes three main exceptions to this rule, allowing courts to consider extra-record evidence:

> (1) if necessary to determine "whether the agency has considered all relevant factors and has explained its decision," (2) "when the agency has relied on documents not in the record," or (3) "when supplementing the record is necessary to explain technical terms or complex subject matter."

*Southwest Ctr. for Biological Diversity v. U.S. Forest Service*,





100 F.3d 1443, 1450 (9th Cir. 1996). A court may also consider extra-record evidence "when plaintiffs make a showing of agency bad faith." *Nat'l Audubon Soc. v. U.S. Forest Serv.*, 46 F.3d 1437, 1447 n.9 (9th Cir. 1993).

DWR maintains that the Sommer declaration explains "technical or complex subject matters" admissible under the exception for evidence "necessary to explain technical or complex subject matters." (Doc. 246-1 at 5-6 n.5.) Plaintiffs move to strike the declaration on the ground that subject matters covered by Mr. Sommer are "neither technical nor complex." (Doc. 305 at 4 n.1.) Rather, Plaintiffs contend that the declaration is offered to explain the agency's post-BiOp experience with DSRAM in an effort to counter the Plaintiffs' argument that the DSRAM is wholly discretionary and contains no defined standards or enforceable requirements.

Generally, "post hoc rationalizations of the agency...cannot serve as a sufficient predicate for agency action." *Am. Textile Manuf. Inst. v. Donovan*, 452 U.S. 490, 539 (1981); *see also Sierra Club v. Bosworth*, 199 F. Supp. 2d 971, 986 (N.D. Cal. 2002)(refusing to consider post hoc explanations that were "neither addressed nor supported by the record"). DWR does not disagree with this general principle, but instead insists that the declaration is offered only to explain complex and technical aspects of the incidental take exceedence levels and the DSRAM.

Paragraphs 11 through 15 of the Sommer Declaration concern the implementation measures taken under the DSRAM after the BiOp issued. There is no basis in the law for the admission of this post-record evidence. DWR does not assert otherwise.

Plaintiffs' motion to strike is **GRANTED** as to paragraphs 11 through 15.

The information contained in the remainder of the Sommers declaration is drawn directly from the BiOp itself, explaining in plain language how the incidental take limits were set and how DSRAM operates. Although, much of the same information can be found in the BiOp, the subject matters covered are technical and complex and Dr. Sommer's declaration clarifies or explains them. This exception saves the remaining paragraphs of the Sommers declaration to explain the incidental take limits.

The motion to strike is **DENIED IN PART** as to the past record evidence paragraphs only.[15]

B. **Federal Defendants' Renewed Objections to Previously Admitted Extra-Record Documents.**

The May 13, 2006 memorandum decision admitted certain extra-record documents, for limited purposes (Doc. 219), including Document 10 (a Powerpoint presentation by Michael Dettinger given to the Bay-Delta Authority on December 8, 2004 entitled "Uncertainties & CALFED Planning What Are Current Observations

[15] In a footnote at the end of Plaintiffs' motion to strike the Sommer Declaration, Plaintiffs also challenge Federal Defendants' reliance on the declaration of Ann Lubas-Williams, which Federal Defendants filed with their response to Plaintiffs' motion for summary judgment/cross motion to dismiss. (*See* Doc. 242-4.) The Lubas-Williams declaration concerns the implementation of DSRAM and the sources from which DWR plans to obtain water to protect Delta smelt in the near future. Federal defendants relied on her declaration primarily to support their motion to dismiss or for voluntary remand. No party has relied upon this declaration in the context of the pending motions; it was not considered by the court. It is unnecessary to rule on this motion to strike.





and Models Saying?") for two purposes. First, "for the limited purpose[] of determining whether []FWS failed to adequately consider the climate change issue and the scientific significance of any such failure....;" but not legal opinions. (Doc. 219 at 25.) Second, to the extent appropriate, all twenty two extra record documents presented by Plaintiffs, including Document 10, may be referenced to aid the court's understanding of various technical concepts under the "technical terms and complex subject matter exception." (*Id.* at 32.)

In the footnote to their opposition brief, Federal Defendants renew their objection to consideration of any of the documents under the technical terms and complex subject matter exception. (Doc. 242-1 at 22 n.12.) The May 13, 2006 memorandum decision notes: "Defendants and Defendant Intervenors suggest that Plaintiff has failed to establish that the existing record is inadequate to explain the technical terms, but point to no authority requiring such a showing." (Doc. 219 at 30.) Federal Defendants now assert: "numerous courts, including the Supreme Court and district courts in this Ninth Circuit, have held that a record may not be supplemented for explanatory purposes unless the existing record has been demonstrated inadequate." (Doc. 242-1 at 22 n.12.), citing an unpublished district court decision, City of *Santa Clarita v. United Stats Dept. Of Interior*, 2005 WL 2972987 at *2 n.3 (C.D. Cal. 2005):

> ...Plaintiffs bear the burden of making an initial showing that the administrative record is inadequate for effective judicial review and that one of the exceptions to record review applies. *Animal Defense Council v. Hodel*, 840 F.2d at 1436-38 (affirming district court order limiting review to administrative record and prohibiting discovery because plaintiffs did

> not show record presented was insufficient for review or that any of the exceptions to record review were applicable)....

(emphasis added).

A district court decision not cited by Defendants, *Karuk Tribe of Cal v. U.S. Forest Serv.*, 379 F. Supp. 2d 1071, 1087 (N.D. Cal. 2005), reiterated this holding:

> The Ninth Circuit allows a reviewing court to consider extra-record materials in an APA case only under four narrow exceptions: (1) when it needs to determine whether the agency has considered all relevant factors and has explained its decision; (2) when the agency has relied upon documents or materials not included in the record; (3) when it is necessary to explain technical terms or complex matters; and (4) when a plaintiff makes a showing of agency bad faith. Southwest Center for Biological Diversity v. United States Forest Service, 100 F.3d 1443, 1450 (9th Cir. 1996). <u>For extra-record material to be considered, a plaintiff must first make a showing that the record is inadequate</u>. *Animal Defense Council v. Hodel*, 840 F.2d 1432, 1437 (9th Cir.1988) ("The [plaintiff] makes no showing that the district court needed to go outside the administrative record to determine whether the [agency] ignored information"). At the *1088 same time, "[a] satisfactory explanation of agency action is essential for adequate judicial review, because the focus of judicial review is not on the wisdom of the agency's decision, but on whether the process employed by the agency to reach its decision took into consideration all the relevant facts." *Asarco, Inc. v. U.S. Environmental Protection Agency*, 616 F.2d 1153, 1160 (9th Cir.1980).

(emphasis added).[16] *Karuk Tribe*, and *Animal Defense Council v.*

[16] Federal Defendants also cite *Pension Benefit Guar. Corp. v. LTV Corp.*, 496 U.S. 633, 654-655 (1990), in which the Supreme Court reasoned: "Here, unlike in *Overton Park*, the Court of Appeals did not suggest that the administrative record was inadequate to enable the court to fulfill its duties under § 706."

Federal Defendants quote *Pension Benefit* entirely out of context. The quoted language is drawn from a part of the opinion addressing the Second Circuit's ruling about the adequacy of <u>procedures</u> used by the defendant agency. Specifically, that court ruled that the agency acted arbitrarily and capriciously





*Hodel*, 840 F.2d 1432, 1437 (9th Cir. 1988), on which it relies, do stand for the proposition that, before admitting documents under any exception to the general rule against extra-record evidence, a court should require that a plaintiff make an initial showing that the existing record is insufficient. Here, defendants maintain that those documents plaintiffs have referenced to explain complex or technical matters, are "the cart before the horse," because Plaintiffs have not shown the existing record is inadequate.

First, Federal Defendants objection is arguably untimely. They did not cite cases requiring a preliminary showing of insufficiency when the motion to augment was briefed and heard. Nor did Federal Defendants timely move for reconsideration of the May 13, 2006 ruling on the motion to augment. Striking the

because it failed to apprise the plaintiff of the material on which it was to base its decision, never gave plaintiff an adequate opportunity to offer contrary evidence, failed to proceed according to ascertainable standards, and failed to provide plaintiff a statement showing its reasoning. *Id.* at 653. One party claimed that *Overton Park* validated a court's order that an agency undertakes additional procedures. *Id.* The Supreme Court rejected this argument, reasoning that, at most, *Overton Park* "imposes a general 'procedural' requirement of sorts by mandating that an agency take whatever steps it needs to provide an explanation that will enable the court to evaluate the agency's rationale at the time of decision." *Id.* at 654. The Supreme Court then distinguished *Overton Park*, reasoning that "[h]ere, unlike in *Overton Park*, the Court of Appeals did not suggest that the administrative record was inadequate to enable the court to fulfill its duties under § 706." *Id.* at 655. This was a specific reference to language in *Overton Park* which criticized the lower courts for relying only on the litigation affidavits, rather than the whole administrative record. *Pension Benefit* sheds absolutely no light on the admissibility of extra-record evidence.

challenged documents now, would cause prejudice to Plaintiffs, who relied upon these rulings to prepare their dispositive motions.

Even assuming a timely and specific objection, on the merits, Plaintiffs' extra-record documents were properly admitted. Of these twenty-two documents, Plaintiffs' papers only referenced eight: Docs. 9, 10, 11, 12, 13, 20, 21 & 22. With the exception of Documents 12 and 22, all were admitted on multiple grounds. (Documents 12 and 22 were admitted for the limited purpose of explaining technical materials.) The documents and the bases for their admission are as follows:

Document 9: Summary of Annual Joint Meeting of California Bay-Delta Authority and Bay-Delta Public Advisory Committee (December 8-9, 2004).

Admitted "for the limited purpose of determining whether USFWS failed to adequately consider the EWA/CVPIA(b)(2) issue," "for the limited purposes of determining whether USFWS failed to adequately consider the climate change issue and the scientific significance of any such failure...," and, as appropriate, to explain complex and technical matters.

Document 10: Climate Change Uncertainties & CALFED Planning: What Are Current Observations and Models Saying? Powerpoint presentation by Michael Dettinger, U.S. Geological Survey at the Scripps Institute for Oceanography, et al. to Bay-Delta Authority (December 8, 2004).

Admitted "for the limited purposes of determining whether USFWS failed to adequately consider the climate change issue and the scientific significance of any such failure," and as appropriate, to explain complex and technical matters.

Document 11: Summary of Annual Joint Meeting of California Bay-Delta Authority and Bay-Delta Public Advisory Committee (February 9-10, 2005).





Admitted for the limited purpose of showing that USFWS failed to consider relevant Delta smelt population data and its scientific significance," and, as appropriate, to explain complex and technical matters.

Document 12: Letter from H. Candee and K. Poole, NRDC, to S. Thompson re Consultation on OCAP: Significant New Delta Smelt Information, Service (Feb. 14, 2005).

Admitted only to explain, as appropriate, complex and technical matters.

Document 13: Delta smelt abundance trends, Powerpoint presentation by Chuck Armor, DFG, to Bay-Delta Authority

Admitted for the limited purpose of showing that USFWS failed to consider relevant Delta smelt population data and its scientific significance," and, as appropriate, to explain complex and technical matters.

Document 20: Supplemental Biological Opinion on CVP and SWP Operations, April 1, 2004 through March 31, 2006 (Feb. 27, 2004).

Admitted "for the limited purpose of determining whether USFWS failed to adequately consider the EWA/CVPIA(b)(2) issue," and, as appropriate, to explain complex and technical matters.

Document 21: Future Water Availability in the West: Will there be enough? Powerpoint presentation by M. Dettinger to 24th Annual Conference on Water, Climate and Uncertainty: Implications for Western Water Law, Policy, and Management (June 11-13, 2003).

Admitted "for the limited purposes of determining whether USFWS failed to adequately consider the climate change issue and the scientific significance of any such failure...," and, as appropriate, to explain complex and technical matters.

Document 22: Letter from John W. Keys, Bureau, to Hon. George Miller, House of Representatives re Bureau's renewal of CVP water contracts (Dec. 23, 2004).

Admitted only to explain, as appropriate, complex and technical matters.

With the exception of Documents 12 and 22, Plaintiffs were permitted to reference these documents to show whether FWS

adequately considered included subject matter to support the BiOp. Although Plaintiffs did not expressly demonstrate that the record was insufficient, a finding of insufficiency can be implied from the rulings admitting the documents. For example, Document 10, the powerpoint presentation regarding "Climate Change Uncertainties & CALFED Planning" presented to the Bay-Delta Authority on December 8, 2004, references climatological information and issues not otherwise discussed in the administrative record, bearing on whether FWS failed to adequately consider the climate change issue. The same reasoning applies to Documents 9, 10, 11, 13, 20 & 21. As for Documents 12 and 22, were which were only admitted under the complex and technical matters exception, no prior showing of insufficiency was made. However, Documents 12 and 22 were only referenced as secondary citations or for context. Even if, any document was admitted in error, no prejudice has resulted.

## V. STANDARD OF REVIEW

Summary judgment is appropriate where there are no genuine issues of material fact and the moving party is entitled to judgment as a matter of law. Fed. R. Civ. Pro. 56(c). This is a challenge to the lawfulness of a biological opinion brought under the ESA and the Administrative Procedure Act ("APA"). Agency decisions made under the ESA are governed by the APA, which requires that the agency action be upheld unless it is found to be "arbitrary, capricious, an abuse of discretion, or otherwise not in accordance with law," or "without observance of procedure required by law." 5 U.S.C. § 706(2)(A), (D). The inquiry is





designed to "ensure that the agency considered all of the relevant factors and that its decision contained no clear error of judgment." *Pacific Coast Fed'n of Fishermen's Ass'ns v. NMFS*, 265 F.3d 1028, 1034 (9th Cir. 2001). Agency action should only be overturned if the agency has "relied on factors which Congress has not intended it to consider, entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise." *Id.* In sum, a court must ask "whether the agency considered the relevant factors and articulated a rational connection between the facts found and the choice made." *Id.* "A biological opinion is arbitrary and capricious and will be set aside when it has failed to articulate a satisfactory explanation for its conclusions or when it has entirely failed to consider an important aspect of the problem." *Greenpeace v. NMFS*, 80 F. Supp. 2d 1137, 1147 (W.D. Wash. 2000). Alternatively, a biological opinion may also be invalid if it fails to use the best available scientific information as required by 16 U.S.C. § 1536(a)(2). *Id.* at 1150.

As a general rule, a court must defer to the agency on matters within its expertise. *See National Wildlife Federation v. National Marine Fisheries Service*, 422 F.3d 782, 798 (9th Cir. 2005). However, "[t]he deference accorded an agency's scientific or technical expertise is not unlimited." *Id.* "Deference is not owed when the agency has completely failed to address some factor consideration of which was essential to [making an] informed decision." *Id.* (internal citations and

quotations omitted).

A final BiOp is final agency action for judicial review purposes. *American Rivers, infra*, 126 F.3d at 1124-25.

## VI. SUMMARY OF PLAINTIFFS' MOTION

Plaintiffs move for summary judgment on the following grounds:

(1) First, the BiOp did not utilize the Best Available Science by: (a) failing to reference the "most recent Delta Smelt abundance data," namely the 2004 Fall Midwater Trawl Data; and (b) failing to consider the possible effects that climate change might have on the smelt's habitat.

(2) Second, the BiOp unlawfully relies upon the DSRAM as a mitigation measure because the DSRAM process is "entirely discretionary, uncertain, and unenforceable." In addition, Plaintiffs allege that Federal Defendants acted arbitrarily and capriciously by relying upon the EWA, CVPIA(b)(2), and/or VAMP programs as water sources necessary to implement the DSRAM. Plaintiffs allege that Federal Defendants have (a) failed to demonstrate that EWA, CVPIA and/or VAMP will continue to be available over the 20-year term of the BiOp and (b) failed to demonstrate that DSRAM can reliably operate without water assets from those programs.

(3) Third, there is no rational connection between the evidence in the record and the BiOp's "no jeopardy" conclusion. Specifically, Plaintiffs allege (a) that the BiOp's focus on salvage as the measure of harm to the species underestimates project impacts and results in a meaningless take limit; and (b)





that the BiOp fails to explain how its no jeopardy conclusion can be justified in light of the identified adverse effects of the project, along with indirect and cumulative effects.

(4) Fourth, the BiOp failed to adequately analyze whether the OCAP's impacts on the Delta smelt's critical habitat are consistent with the smelt's recovery. In addition, the Federal Defendants failed to adequately take into account smelt habitat areas other than defined by X2.

(5) Finally, the BiOp is unlawfully narrow in its scope because it (a) fails to provide a comprehensive analysis of the effects of constructing facilities required to carry out long term CVP and SWP operations and (b) fails to analyze the impacts of the projects delivering the full amount of water authorized under CVP and SWP water service contracts.

## VII. DISCUSSION

### A. Threshold Issues.

#### 1. ESA 60-day notice requirement.

The San Luis Parties argue that Plaintiffs have not complied with the ESA's citizen suit notice requirement, 16 U.S.C. § 1540(g)(2)(A)(I), that written notice be given to "the Secretary, and to any alleged violator" at least sixty days in advance of filing suit. Failure to give this notice is a bar to bringing suit under the ESA. *Southwest Ctr. for Biological Diversity v. U.S. Bureau of Reclamation*, 143 F.3d 515, 520 (9th Cir. 1998).

In *American Rivers v. National Marine Fisheries Serv.*, 126 F.3d 1118, 1124-25 (9th Cir. 1997), the Ninth Circuit held that issuance of a biological opinion is a final agency action that is

properly pled as a challenge under the APA, rather than as a citizen suit claim under the ESA. Failure to comply with the 60-day notice requirement does not deprive the court of jurisdiction. *Id.*

The San Luis Parties advocate an approach that ignores *American Rivers*,[17] taken in an unpublished district court opinion, *Pacific Coast Fed' of Fishermen's Ass'ns v. U.S. Bureau of Reclamation*, 2006 WL 1469390 at 27 n.8 (N.D. Cal. 2006). *Pacific Coast Federation* declined to apply *American Rivers'* general rule because the injunctive relief the Plaintiffs sought went beyond simply having the biological opinion invalidated. The *Pacific Coast Federation* Plaintiffs sought to have any new biological opinion first reviewed by the court. This requested relief, fell outside the scope of the APA but was "within the scope of the ESA and thus trigger[ed] the notice period requirement." *Id.* Here, the requested relief is invalidation of the BiOp, a remedy undeniably available under the APA. *American Rivers* controls. There was no need to comply with the ESA 60-day notice requirement. The district court has jurisdiction over APA review of the BiOp.

**2. Jurisdiction to Review Challenges to Early Consultation and Preliminary Biological Opinion.**

Defendants contend the case is not ripe for decision. The BiOp covers not only current operations, but also a variety of future actions, some subject to formal consultation, others to

[17] At least one district court has followed the holding in *American Rivers*. *See NRDC v. Rodgers*, 381 F. Supp. 2d 1212, 1230 (E.D. Cal. 2005).





early consultation:

> This biological opinion covers formal and early consultation for the operations of the CVP and SWP. The formal consultation effects described in this biological opinion cover the proposed 2020 operations of the CVP including the Trinity River Mainstem ROD (Trinity ROD) flows on the Trinity River, the increased water demands on the American River, the delivery of CVP water to the proposed Freeport Regional Water Project (FRWP), water transfers, the long term Environmental Water Account (EWA), the operation of the Tracy Fish Facility, and the operation of the SWP-CVP intertie. The effects of operations of the SWP are also included in this opinion and include the operations of the North Bay Aqueduct, the Suisun Marsh Salinity Control Gates, the Skinner Fish Facility and water transfers.
>
> Early consultation [issues address] the effects of operations of components of the South Delta Improvement Program (SDIP). These operations include pumping of 8500 cubic feet per second (cfs) at the SWP and Banks Pumping Plant (hereafter referred to as 8500 Banks), permanent barrier operations in the South Delta, the long term EWA, water transfers, and CVP and SWP operational integration. There are two separate effects sections in this biological opinion, one for Formal Consultation and one for Early Consultation. In addition, there is an incidental take for formal consultation and a preliminary incidental take for early consultation.

(AR 2, 248.)

The San Luis Parties object that the early consultation portions of the BiOp are not final agency action and any challenges to the early consultation process are not subject to judicial review. Early consultation, by definition, results in only a "preliminary opinion" and in a preliminary incidental take statement that "does not constitute authority to take listed species." 50 C.F.R. § 402.11(e). Upon request for "confirmation" of a preliminary biological opinion, FWS will review the proposed action to determine if there have been "significant changes in the action as planned or in the

information used during early consultation." § 402.11(f). Within 45 days of such request, FWS must either confirm the preliminary biological opinion or request formal consultation. *Id.*

Plaintiffs concede that they "are not challenging the validity of FWS's early consultation or its preliminary biological opinion regarding certain segregated components of the 2004 OCAP." (Doc. 306 at 37.) Rather, Plaintiffs argue that the portion of the BiOp covering formal consultation is flawed because it fails to examine the full impacts of all aspects of the 2004 OCAP. (Doc. 306 at 37.) Plaintiffs maintain the formal consultation should have covered certain planned actions included in the early consultation that are interdependent with other planned actions not included in either consultation. This claim is cognizable, as it challenges the scope of the formal consultation and the completeness of evaluation of overall OCAP operations on jeopardy to the smelt, not the lawfulness of the early consultation on future actions.

**B. The Biological Opinion Unlawfully Relies Upon Uncertain, Unenforceable Mitigation Measures.**

The BiOp concludes that the "operations of the Projects under formal consultation...will result in adverse effects to the delta smelt through entrainment at the CVP and SWP facilities and by drawing delta smelt into poorer quality habitat in the south delta. However with the inclusion of the conservation measures described above and the implementation of the DSRAM, these adverse effects would be avoided or minimized." (AR 467 (emphasis added).) The "conservation measures" mentioned in the





BiOp's conclusion are various regulatory mechanisms already in place to "provide protection to delta smelt and/or their habitats," including D-1641, the EWA, CVPIA (b)(2) water, and VAMP. (AR 421-22, 466-67.)

**1. Law Governing Mitigation Measures.**

Mitigation measures must be "reasonably specific, certain to occur, and capable of implementation; they must be subject to deadlines or otherwise-enforceable obligations; and most important, they must address the threats to the species in a way that satisfies the jeopardy and adverse modification standards." *Ctr. for Biological Diversity v. Rumsfeld*, 198 F. Supp. 2d 1139, 1152 (D. Ariz. 2002)(citing *Sierra Club v. Marsh*, 816 F.2d 1376 (9th Cir. 1987)); *see also NWF v. NMFS*, 481 F.3d 1224 at *12 & n.16 ("Although the record does reflect a general desire to install structural improvements [to benefit fish] where feasible, it does not show a clear, definite commitment of resources for future improvements.").

Plaintiffs allege that, in depending on the DSRAM and the other "conservation measures" to support its no jeopardy conclusion, the BiOp unlawfully relies upon uncertain, unenforceable mitigation measures which do not constitute a clear, definite commitment of resources. Specifically, Plaintiffs argue: (a) the DSRAM process is "entirely discretionary, uncertain, and unenforceable and (b) the biological opinion unjustifiably assumes that the other, currently operational "conservation measures" (e.g., the EWA and CVPIA(b)(2) water) will continue to be available for use by DSRAM in the future.

**2. The DSRAM is Unlawfully Uncertain and Unenforceable.**

All Defendants argue that the DSRAM is an effective adaptive management program that provides the agency the necessary remedial flexibility that makes the BiOp lawful. The BiOp describes the DSRAM as follows:

> The delta smelt risk assessment matrix (DSRAM) consists of month by month criteria which, when exceeded will trigger a meeting of the Delta Smelt Working Group (Working Group). The purpose of the DSRAM is to take actions to protect delta smelt in a proactive manner prior to salvage events....The DSRAM is an adaptive management tool which may be further modified by the Working Group/WOMT as new information becomes available, without undergoing formal reconsultation.... Data will be updated at least weekly to determine the need for a meeting.
>
> Should a triggering criterion be met or exceeded, Reclamation and/or DWR will inform the members of the Working Group and the Working Group will determine the need to meet. Any member of the Working Group may set up a meeting of the Working Group at any time. A meeting of the Working Group may consist of an in-person meeting, a conference call, or a discussion by email. If needed, the Working Group will meet prior to the weekly meetings of the DAT and the WOMT and information will be shared with these groups.
>
> Should a meeting of the Working Group prove necessary, the group will decide whether to recommend a change in exports, change in south delta barrier operations, San Joaquin River flows, or a change in delta cross channel operations, and the extent and duration of the potential action. These potential actions are listed in the DSRAM by the months wherein each of these tools generally become available. The group will recommend actions which will be shared with the DAT and forwarded to the WOMT for discussion and potential implementation. This recommendation will include a discussion of the level of concern for delta smelt and will include who participated in the working group discussions. All dissenting opinions and/or discussion points will also be forwarded to the WOMT. The Working Group will meet at least weekly throughout the period in which the triggering criteria are met or exceeded, to determine the need to provide further recommendations to the WOMT.
>
> Notes and findings of Working Group meeting will be





> submitted to the Service and members of the WOMT for their records. The WOMT will respond to the Working Group's recommendations and the actions taken by the WOMT will be summarized by Reclamation and/or DWR annually and submitted to all WOMT agencies.
>
> If an action is taken, the Working Group will follow up on the action to attempt to ascertain its effectiveness. An assessment of effectiveness will be attached to the notes from the Working Group's discussion concerning the action.

(AR 344-45 (emphasis added).)

The trigger criteria, which vary slightly from month to month, are set forth in a table (or matrix) at page 100 of the BiOp. (AR 346.) The criteria include: (1) the previous year's fall midwater trawl recovery index; (2) the risk of smelt entrainment based upon the location of X2; (3) the estimated duration of the smelt spawning period based upon water temperature; (4) the presence of spawning female smelt; (5) the proximity of the smelt to the Project pumping facilities; and, (6) a salvage trigger for adult smelt (calculated as the ratio of adult smelt salvage to the FMWT index) and juvenile smelt (set at zero for May and June, the months of the year during which salvage of smelt is highest). (AR 346-49.)

Plaintiffs argue that the DSRAM is not "reasonably specific, certain to occur, and capable of implementation" because: (1) the DSWG has complete discretion over whether to meet and whether to recommend mitigation measures; (2) even if the DSWG meets and recommends mitigation measures, the WOMT group is free to reject any recommendations; (3) there are no standards to measure the effectiveness of actions taken; (4) reconsultation is not required should mitigation measures prove ineffective; and (5) ultimately, no action is ever required.

DWR responds that implementation of the DSRAM process is "mandatory." For example, the incidental take statement requires that the projects shall be implemented "as described" in the BiOp. (AR 475.) Because the BiOp "describes" operation of the DSRAM, DWR asserts that its implementation is made mandatory by the incidental take statement's command that the project shall be implemented "as described;" if a DSRAM triggering criteria is met, the DSWG "will determine the need to meet." (AR 344 (emphasis added).) If circumstances warrant action, the DSWG will recommend fish protection actions and forward those recommendations to the WOMT. (*Id.*) The BiOp provides that the DSWG "will meet at least weekly throughout the period in which the triggering criteria are met or exceeded, to determine the need to provide further recommendations to the WOMT." (*Id.* at 345 (emphasis added).) The WOMT must then "respond" to DSWG's recommendations. (*Id.*) If actions are taken, the DSWG will monitor the action to determine its effectiveness. (*Id.*)

DWR correctly asserts that the DSRAM process must be followed; this does not address Plaintiffs' argument: that the DSRAM process itself does not require any mitigation actions be taken. Nothing in DSRAM requires the DSWG to make action recommendations, whatever the circumstances, and no criteria prescribe when the WOMT must act to effect DSWG's recommendations.

DWR responds that as adaptive management, "DSRAM is intentionally flexible, taking into consideration the uncertainties surrounding delta smelt population abundance and dynamics...[D]elta smelt abundance has fluctuated widely, without





a clear explanation why. While experts can monitor trends in delta smelt populations, estimating overall population abundance presently is 'not possible,' nor are the sources of year-to-year variability in abundance well understood." (Doc. 246-1 at 12. ) DWR suggests that "hard-wiring" the DSRAM to require specific actions be taken when triggering criteria occur would impair the DSRAM's flexibility. For example, the trigger for salvage of juvenile smelt is set at zero. This trigger was designed not to precipitate a meeting every time that standard is exceeded, but to cause heightened awareness of conditions that might require protective action. (Doc. 246-1, at 12, citing AR at 8217-18.)

The conflict between Defendants' choice of a flexible management approach and Plaintiffs' concern to ensure enforceable protective actions are taken when necessary, highlights the extent to which overly flexible adaptive management may be incompatible with the requirements of the ESA. Commentators recognize that adaptive management schemes do not fit neatly within the ESA's existing regulatory structure. *See J.B. Ruhl*, Taking Adaptive Management Seriously: A Case Study of the Endangered Species Act, 52 U. Kan. L. Rev. 1249, 1284 (2004)("The [ESA] as a whole lacks a cohesive adaptive management architecture...."). H. Doremus, *Adaptive Management, The Endangered Species Act, and the Institutional Challenges of "New Age" Environmental Protection*, 41 Washburn. L. J. 50, 52 (2000)("Adaptive Management...runs counter to human nature and the current structure of our management institutions."); ("One key institutional challenge is to combine the flexibility required by adaptive management with the long-term certainty we

often seek through our legal and political institutions.") 41 Washburn L. J. at 55.

The case law sheds little light on how to harmonize these competing objectives. The parties cite no cases applying the "reasonably specific, certain to occur, and capable of implementation" concept (or any closely related doctrine) to mitigation measures employed under an adaptive management protocol. Most cases the parties cite are either wholly inapplicable or factually distinguishable.

For example, mitigation measures have been found unlawfully uncertain because their implementation was not within the control of the relevant federal agencies. *National Wildlife Federation v. NMFS*, 254 F. Supp. 2d 1196, 1213 (D. Or. 2003), invalidated a 2000 biological opinion addressing the effects of the operation of the Federal Columbia River Power System ("FCRPS") on several listed fish species. A 2000 biological opinion concluded that continued operation of the FCRPS would jeopardize several of the species and adversely modify their critical habitat and adapted mitigation measures to avoid jeopardy. The mitigation measures included a variety of short- and long-term state, regional, tribal, and private off-site mitigation actions. The plaintiffs argued that reliance on such "uncertain and vaguely defined actions of third parties to protect and restore salmon habitat," violated the "reasonably certain to occur" standard. *Id.* at 1209. The district court agreed, concluding that the no jeopardy determination unlawfully relied on "non-federal off-site mitigation actions that are not reasonably certain to occur." *Id.* at 1214. *See also Sierra Club v. Marsh*, 816 F.2d 1376, 1385





(9th Cir. 1987)(invalidating biological opinion that relied on mitigation measure involving the transfer of 188 acres of marshland from private ownership to a publicly owned wildlife refuge; land remained under private control and subject to easements that rendered the land valueless for mitigation purposes, and private owners and local government indicated intent to increase use of one of the easements); *Oregon Natural Desert Ass'n v. Lohn*, --- F. Supp. 2d ---, 2007 WL 1170629 (D. Or. 2007)(setting aside biological opinion in part because it overly relied on the actions of private individuals who had a poor past record of compliance with standards); *Florida Key Deer v. Brown*, 364 F. Supp. 2d 1345, 1355-56 (S.D. Fla. 2005)(setting aside biological opinion that relied on mitigation measures to be implemented by private landowners; nothing compelled the landowners to act and "the record indicate[d] that some landowners entirely disregarded [prior mitigation measures]").

Here, the BiOp's mitigation measures <u>are</u> largely under the control of the action agency (the Bureau), which, operating in concert with the DWR, directly regulates water pumping and releases from upstream reservoirs. *Natural Resources Defense Council v. Rodgers*, 381 F. Supp. 2d 1212, 1241 (E.D. Cal. 2004), does not provide guidance. In that case, plaintiffs contended a BiOp's mitigation measures were not reasonably certain to occur because the action agency had a poor track record of following through on prior commitments. The acknowledging that the agency's track record was "discouraging" district court recognized that the agency had made some progress toward implementing its prior commitments, *id.*, and declined to find

that the new commitments were not certain to occur. *Id.* However, the *Rogers* plaintiffs did not attack the efficacy of the mitigation measures themselves, only the likelihood that the agency would not satisfy its commitment to implement them. Here, Plaintiffs challenge the inherent uncertainty and unenforceability of the DSRAM and the other conservation measures.

Plaintiffs cite *American Rivers v. U.S. Army Corps of Engineers*, 271 F. Supp. 2d 230, 252 (D.D.C. 2003), where, despite the fact that a prior biological opinion required the Corps to implement flow restrictions to mitigate impacts to listed species, the Corps "made it perfectly clear" to the district court "that it ha[d] no intention of ensuring that its future operations will be consistent" with the mitigation requirements. *Id.* at 253. A motion for preliminary injunction was granted: "Plaintiffs will be likely to prove that the 2003 Supplemental BiOp violated the ESA and APA by improperly and unreasonably relying on future actions by the Corps that are virtually certain not to occur." *Id.* at 254 (emphasis added). Here, in contrast, there is no such "smoking gun" evidence of the agency's intent to disregard its mitigation responsibilities, just no definite, certain, or enforceable measures.

*Center for Biological Diversity v. Rumsfeld*, 198 F. Supp. 2d 1139, 1151-53 (D. Ariz. 2002) addressed a biological opinion that concluded the Army's continued operations at Fort Huachuca, Arizona would not cause jeopardy to listed species that relied on flows from the Upper San Pedro River, even though rapid development in the area and uncontrolled groundwater pumping at





the Fort posed threats to the species. The "no jeopardy" finding was premised on several required mitigation measures.

First, the Army had to develop and implement an on-base plan to protect and maintain populations of listed species and habitats; *id.* at 1148, even though the on-base plan was not designed to address the underlying problem of diminishing flows in the San Pedro River, *see id.* at 1153. Second, the Army had to develop a regional water resources plan, sufficient to maintain flows in the San Pedro River to sustain the protected species and their habitats. *Id.* at 1148. The biological opinion acknowledged, that the Army had no authority over the implementation of the regional plan and was only required to participate along with other stakeholders. *Id.* at 1153. Third, the Army had to monitor progress and report on the implementation of the various projects. *Id.* at 1149. Fourth, the biological opinion assumed the operation of a water recharge facility designed to temporarily delay the impact of groundwater overdraft, which the *Rumsfeld* court acknowledged was "subject to substantial uncertainty." *Id.* at 1145.

Leaving it to the Army and other interested parties to develop a regional water management plan "enables the Army to sidestep any direct responsibility for addressing deficit groundwater pumping," and was "an admission that what is currently on the table as far as mitigation measures is inadequate to support the [] 'no jeopardy' decision." 198 F.

Supp. 2d at 1153-54.[18]

DWR distinguishes *Rumsfeld*, claiming it is like *NWF v. NMFS*, 254 F. Supp. 2d 1196, where mitigation measures were unlawful because they depended upon third parties without any guarantee that those parties would implement the measures. Here, the DSRAM does not depend on actions by outsiders. *Rumsfeld* further found that the Army's on-base mitigation measures were insufficient because they did not require any measurable goals or an implementation schedule:

> There are no requirements in the Final BO to reduce reliance on groundwater pumping by any particular

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[18] *Rumsfeld* also found fault with the biological opinion's monitoring plan, characterizing it as a means of delaying the implementation of necessary mitigation measures:

> The Army may not delay identifying the measures necessary to mitigate the effects of its ten-year plan based on the monitoring provisions in the Final BO....
>
> The Final BO's monitoring requirements do not measure the success or failure of the on-base and/or regional mitigation measures to reduce the groundwater deficit. It only requires the Army to develop "a monitoring program designed to assess progress," and requires an annual review of the AWRMP, as to which projects have been implemented the past year and which are to be implemented in the coming year. Especially since the Final BO and the AWRMP fail to quantify the remedial value of the proposed projects, simply reporting project implementation is not a meaningful assessment of the success or failure of the mitigation measures in protecting the water umbel, willow flycatcher, and critical habitat from adverse impact. Such an assessment would require systematic monitoring of either San Pedro baseflows or the groundwater aquifer.

198 F. Supp. 2d at 1154 (internal record citations omitted). No such failure is alleged here. Plaintiffs do not suggest that the monitoring called for by the DSRAM is flawed.





> amount or to achieve any measurable goals with respect to water recharge. There is no date certain implementation requirement. The MOA includes a laundry list of possible mitigation measures related to water conservation and recharge that the Army may implement, but it does not establish which projects have to be undertaken, when, nor what the conservation objectives are for the respective projects. Without such specificity, the mitigation measures in the Final BO are merely suggestions.

*Id.* at 1153 (emphasis added). *Rumsfeld* stands for the proposition that, at a minimum, a mitigation strategy must have some form of measurable goals, action measures, and a certain implementation schedule; i.e., that mitigation measures must incorporate some definite and certain requirements that ensure needed mitigation measures will be implemented.

Here, the agency's BiOp admits that mitigation measures are essential. The no jeopardy finding is conditioned on conservation measures and the DSRAM. (*See* AR 422.)

DWR's protestations that hard-wiring the DSRAM would cripple its effectiveness ignore the ESA's requirements of reasonable certainty, timetables, and enforceability standards for mitigation measures. The existing DSRAM process provides absolutely no certainty that any needed smelt protection actions will be taken at any time by DSWG or WOMT. The DSRAM is in substance an organizational flow chart that prescribes that certain administrative processes (meetings) will be held whenever a trigger criteria is met or exceeded. Although mitigation measures are identified, no defined mitigation goals are required, nor is any time for implementation prescribed. Incorporating some ascertainable mitigation standards and enforceable mitigation measures is not inconsistent with avoiding

unduly restrictive "hard-wiring" of the DSRAM.

*National Wildlife Federation v. Babbit*, 128 F. Supp. 2d 1274 (E.D. Cal. 2000) ("*NWF v. Babbit*"), addresses an adaptive management approach that accommodated uncertainty by allowing regulators to apply new information gathered through monitoring to adjust and employ well-defined mitigation measures. There, a Habitat Conservation Plan ("HCP") called for a development fee to be collected on all acreage developed in the Natomas Basin, north of Sacramento, home to a number of endangered species. The HCP also incorporated adaptive management provisions designed to allow the mitigation fee to be modified if new information justified an adjustment:

> The [HCP] recognizes that the current state of knowledge as to the conservation needs of protected species is imperfect, and that its assumptions as to the amount, location, and pace of development in the Basin and as to the adequacy of the mitigation fee to accommodate increased expenses may prove inaccurate. The Plan addresses these uncertainties through its "adaptive management" provisions, which permit the Plan's conservation strategy to be adjusted based on new information. The HCP's conservation program can be modified under the adaptive management provisions if: (1) new information results from ongoing research on the GGS or other covered species; (2) recovery strategies under Fish and Wildlife Service recovery plans for the GGS or the Swainson's hawk differ from the measures contemplated by the HCP; (3) certain of the HCP's mitigation measures are shown through monitoring to require modification; or (4) the HCP's required minimum block sizes for reserve lands are shown to require revision. The Plan anticipates that the NBC will make discretionary decisions in future years based upon new information. The NBC will decide, for example, which lands to purchase, depending on a variety of future considerations difficult now to predict, and whether to change the mix of in and out of Basin reserve lands and agricultural as opposed to marsh reserve lands.





*Id.* at 1281-82.[19]

Here, the adaptive management process has no quantified objectives or required mitigation measures. Although the process must be implemented by holding meetings and making recommendations, nothing requires that any actions ever be taken.[20] The BiOp asks the court to trust the agency to protect the species and its habitat. Notwithstanding any required deference to expertise, the ESA requires more.

All parties agree that adaptive management can be beneficial and that flexibility is a necessary incident of adaptive management. The law requires that a balance be struck between the dual needs of flexibility and certainty. The DSRAM, as currently structured, does not provide the required reasonable certainty to assure appropriate and necessary mitigation measures will be implemented. The DSRAM does not provide reasonable assurance admitted adverse impacts of the 2004 OCAP will be mitigated. This aspect of the BiOp is arbitrary and capricious

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[19] In *NWF v. Babbit*, the district court expressly approved the design of the HCP as a whole, but invalidated the permit issued in connection with the plan on grounds wholly independent from the design of the HCP and/or the adaptive management plan. *See 128 F. Supp. 2d* at 1298-99.

[20] The only clearly enforceable standard or benchmark in the BiOp is compliance with the BiOp's "hard" take exceedence limits. But, the existence of enforceable take limits does not shield the DSRAM from scrutiny. There is no provision to allow the "hard" take exceedence limits to be adjusted to reflect new information about the species. Moreover, the BiOp expressly recognizes that the take limits alone are not enough to prevent jeopardy, requiring, among other things, implementation of the DSRAM as a reasonable and prudent measure. (*See* AR 475 ("The Project shall be implemented as described.") This is exactly the reason why the DSRAM must be made more certain and enforceable.

and contrary to law. Plaintiffs' motion for summary adjudication as to this claim is **GRANTED**. The agency has not provided a reasonable explanation showing the DSRAM will satisfy ESA requirements to assure survival and recovery of the Delta smelt.

The Ninth Circuit's *recent NWF v. NMFS* decision suggests that mitigation measures that are not reasonably certain to occur should be excluded from the agency's no jeopardy analysis. *See* 481 F.3d 1224 at *12 n.16.[21] Because mitigation is insufficiently certain to occur under the DSRAM, the DSRAM cannot cure other shortcomings of the BiOp.

**3. Plaintiffs' Alternative Argument that the BiOp is Arbitrary and Capricious Because DSRAM Depends Upon EWA, VAMP, CVPIA(b)(2) Water, Programs that are Uncertain in Terms of Funding and Effectiveness.**

Plaintiffs maintain that the DSRAM cannot feasibly be implemented without adequate water assets from the EWA, CVPIA(b)(2), and VAMP programs. Plaintiffs allege that Defendants have not demonstrated that adequate assets from these programs will be available during the 20 year term of the BiOp. (*See* Doc. 306 at 17.)

Plaintiffs correctly observe that the BiOp does not assure that adequate water assets from these programs will be available for future use under DSRAM. The BiOp itself acknowledges that "[a]lthough VAMP and [EWA] have helped to ameliorate these threats, it is unclear how effective these will continue to be over time based on available funding and future demands for

[21] As of the date of oral argument, the mandate has not yet issued in *NWF v. NMFS*.





water." (AR 367-68.) The BiOp recognizes that the "EWA Agencies envision implementation of a long-term EWA as part of the operation of the Project." (AR 335.) However, the BiOp cannot and does not commit to implement the EWA in the long run. (*Id.*)

The record reveals that the loss of EWA assets will "reduce the ability of the EWA agencies to provide [] fish protections...." (SAR 20.) Plaintiffs refer to statements made by FWS's D. Harlow during an annual joint meeting of CALFED and the Bay-Delta Public Advisory Committee, that a proposal to change CVPIA(b)(2) policy would "change fish protection envisioned in the Record of Decision (ROD)." (Doc. 9 at 4.) At the same time, Mr. Harlow also noted that this would "not necessarily diminish fish protection." (*Id.*) However, he opined that such a change would "necessitate an increase in the size of the EWA." (*Id.*) National Oceanic and Atmospheric Administration ("NOAA") staff questioned FWS's reliance on the EWA in the BiOp, noting that EWA assets would likely be used up for protective actions during the winter, before the peak months for Delta smelt salvage (May and June). (AR 8574.)

Plaintiffs' claim rests in part on the assumption that the EWA, CVPIA(b)(2), and VAMP programs are the <u>only</u> mechanisms by which DSRAM may be implemented. The record does not support this assumption. Under the BiOp, the DSWG is tasked to make recommendations regarding fish protection actions by selecting from a list of "tools for change," which include: (1) "export reduction[s] at one or both facilities"; (2) "change[s] in barrier operations"; (3) "change[s] in San Joaquin River flows"; and (4) "change[s] [in the] position of cross channel gates." (AR 346 and 348 n.7.) No mention is made of the EWA,

CVPIA(b)(2), or VAMP in the DSRAM or its description of the "tools for change." DWR rejoins that, regardless of whether these programs are fully funded and/or remain functional mechanisms to provide water to the Delta, "the burden....falls on the Projects, not the smelt." (Doc. 246 at 10.)

The EWA is simply a means by which the SWP and CVP can obtain water by purchasing it from willing sellers. (AR 373.) EWA water may be used either to protect fish or to compensate project water users for reduced exports at the project pumps. (*Id.*) If money is unavailable to fund the EWA, Defendants are nonetheless required to prevent smelt take from exceeding permissible take limits.

The BiOp sets forth a three-tier process to supply water to protect the smelt:

> • Tier 1 (Regulatory Baseline). Tier 1 is baseline water and consists of currently existing BOs, water right decisions and orders, CVPIA Section 3406(b)(2) water, and other regulatory actions affecting operations of the CVP and SWP. Also included in Tier 1 are other environmental statutory requirements such as Level 2 refuge water supplies.
>
> • Tier 2 (EWA). Tier 2 is the EWA and provides fish protection actions supplemental to the baseline level of protection (Tier 1). Tier 2 consists of EWA assets, which combined with the benefits of CALFED's ERP, will allow water to be provided for fish actions when needed without reducing deliveries to water users. EWA assets will include purchased (fixed) assets, operational (variable) assets, and other water management tools and agreements to provide for specified level of fish protection. Fixed assets are those water supplies that are purchased by the EWA Agencies. These purchased quantities are approximations and subject to some variability. Operational assets are those water supplies made available through CVP and SWP operational flexibility. Some examples include the flexing of the export-to-inflow ratio standard required [] for meeting Delta water quality and flows, and ERP water resulting from upstream releases pumped at the SWP Banks Pumping Plant. Water management tools provide the ability to





> convey, store, and manage water that has been secured through other means. Examples include dedicated pumping capacity, borrowing, banking, and entering into exchange agreements with water contractors. Chapter 8 of this BA contains a more detailed description of EWA operations, as characterized in the CALSIM II modeling for the CVP OCAP.
>
> • Tier 3 (Additional Assets). In the event the EWA Agencies deem Tiers 1 and 2 levels of protection insufficient to protect at-risk fish species in accordance with the Act, Tier 3 would be initiated. Tier 3 sets in motion a process based upon the commitment and ability of the EWA Agencies to make additional water available, should it be needed. <u>This Tier may consist of additional purchased or operational assets, funding to secure additional assets if needed, or project water if funding or assets are unavailable</u>. It is unlikely that protection beyond those described in Tiers 1 and 2 will be needed to meet requirements of the Act.

(*Id.* at 336-37.) DWR emphasizes that, if all else fails, Tier 3 assets may be brought to bear, which include "additional purchased or operational assets, funding to secure additional assets if needed, or <u>project water</u> if funding or assets are unavailable." (*Id.* (emphasis added).)

There is a difference between the DSRAM's failure to require mitigation actions in response to trigger events, designed to assure the commitment of necessary resources to smelt protection, and the duty to have available or acquire those necessary resources. A court must leave to the agency the application of its expertise and authority to manage the complex hydrologic, legal, financial, physical, and logistical aspects of protecting the delta smelt. Plaintiffs motion for summary adjudication is **DENIED** as to the issue of the insufficiency of the EWA, VAMP, and CVPIA(b)(2) programs.

C. **<u>Best Available Science</u>**.

The § 7 formal consultation process is designed to "insure"

that any agency action "is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species which is determined...to be critical...." 16 U.S.C. § 1536(a)(2). "In fulfilling the requirements of this paragraph each agency shall use the best scientific and commercial data available." *Id.*

An agency has wide discretion to determine what is "the best scientific and commercial data available." *San Luis v. Badgley*, 136 F. Supp. 2d 1136, 1151 (E.D. Cal. 2000). Yet, an agency must make its decision about jeopardy based on the best science available at the time of the decision, and may not defer that jeopardy analysis by promising future studies to assess whether jeopardy is occurring. *Rumsfeld*, 198 F. Supp. 2d at 1156. While uncertainty is not necessarily fatal to an agency decision, *e.g.*, *Greenpeace Action v. Franklin*, 14 F.3d 1324, 1337 (9th Cir. 1992) ("*Greenpeace I*") (upholding agency decision even though there was uncertainty about the effectiveness of management measures because agency premised its decision on a reasonable evaluation of all available data), an agency may not entirely fail to develop appropriate projections where data "was available but [was] simply not analyzed," *Greenpeace v. NMFS*, 80 F. Supp. 2d 1137, 1149-50 (W.D. Wash. 2000) ("*Greenpeace II*") (where agency totally failed to develop any projections regarding population viability, it could not use as an excuse the fact that relevant data had not been analyzed). Here, EWS maintains the necessary data cannot be obtained.





**1. Does a "Benefit of the Doubt to the Species" Presumption Apply?**

The parties debate at length whether the best available scientific information principle includes a requirement that the agency "give the benefit of the doubt to the species." This language has its origins in the legislative history of the ESA, H.R. Conf. Rep. No. 96-697, 96th Cong., 1st Sess. 12, reprinted in 1979 U.S.C.C.A.N. 2572, 2576:

> Section 7(b) of the act requires the fish and wildlife service and the national marine fisheries service to render biological opinions which advise whether or not proposed agency actions would violate section 7(a)(2). Courts have given substantial weight to these biological opinions as evidence of an agency's compliance with section 7(a). The amendment would not alter this state of the law or lessen in any way an agency's obligation under section 7(a)(2).
>
> As currently written, however, the law could be interpreted to force the fish and wildlife service and the national marine fisheries service to issue negative biological opinions whenever the action agency cannot guarantee with certainty that the agency action will not jeopardize the continued existence of the listed species or adversely modify its critical habitat. The amendment will permit the wildlife agencies to frame their section 7(b) opinions on the best evidence that is available or can be developed during consultation. If the biological opinion is rendered on the basis of inadequate information then the federal agency has a continuing obligation to make a reasonable effort to develop that information.
>
> <u>This language continues to give the benefit of the doubt to the species</u>, and it would continue to place the burden on the action agency to demonstrate to the consulting agency that its action will not violate section 7(a)(2). Furthermore, the language will not absolve federal agencies from the responsibility of cooperating with the wildlife agencies in developing adequate information upon which to base a biological opinion. If a federal agency proceeds with the action in the face of inadequate knowledge or information, the agency does so with the risk that it has not satisfied the standard of section 7(a)(2) and that new information might reveal that the agency has not satisfied the standard of section 7(a)(2).

(emphasis added).

In *Conner v. Burford*, 848 F.2d 1441, 1454 (9th Cir. 1988), the Ninth Circuit applied this "benefit of the doubt" language to hold that FWS violated the ESA by "failing to use the best information available to prepare comprehensive biological opinions considering all stages of the agency action...." At dispute in *Conner* was a biological opinion reviewing the proposed sale of oil and gas leases on National Forest land. The biological opinion analyzed the impact of the "initial lease phase," but failed to address the potential impact of post leasing activities, such as oil and gas development. FWS reasoned that there was "insufficient information available to render a comprehensive biological opinion beyond the initial lease phase," relying instead on "incremental-step consultation." *Id.* at 1452. The Ninth Circuit recognized that "the precise location and extent of future oil and gas activities were unknown at the time," but, "extensive information about the behavior and habitat of the species in the areas covered by the leases was available." *Id.* at 1453. With this information, "FWS could have determined whether post-leasing activities in particular areas were fundamentally incompatible with the continued existence of the species." *Id.* at 1454.

> In light of the ESA requirement that the agencies use the best scientific and commercial data available to insure that protected species are not jeopardized, 16 U.S.C. § 1536(a)(2), the FWS cannot ignore available biological information or fail to develop projections of oil and gas activities which may indicate potential conflicts between development and the preservation of protected species. We hold that the FWS violated the ESA by failing to use the best information available to prepare comprehensive biological opinions considering all stages of the agency action, and thus failing to





> adequately assess whether the agency action was likely to jeopardize the continued existence of any threatened or endangered species, as required by section 7(a)(2). To hold otherwise would eviscerate Congress' intent to "give the benefit of the doubt to the species."

*Id.* (emphasis added). *Conner* does not directly support the broader interpretation urged by Plaintiffs, that the agency should err on the side of the species when evaluating uncertain evidence. *Conner* stands for the proposition that an agency cannot abdicate its responsibility to evaluate the impacts of an action on a species by labeling available information "uncertain," because doing so violates Congress' intent that the agencies "give the benefit of the doubt to the species."

*Center for Biological Diversity v. Lohn*, 296 F. Supp. 2d 1223, 1239 (W.D. Wash. 2003)(rev'd on other grounds, --- F.3d ---, 2007 WL 1217738 (9th Cir.)), applied the *Conner* holding in conformity with Plaintiffs' interpretation. *Lohn* addressed the listing under the ESA of a population of orca whales. Despite considerable record evidence suggesting the Orca whales should be considered a separate species, the Orca population had not yet been identified as a separate taxon. NMFS decided not to list the species based on the scientific uncertainty that existed in the field of taxonomy, relying on the fact that the new taxon had not yet been designated. The district court ruled this decision was arbitrary and capricious:

> Given the considerable morphological, behavioral, and genetic evidence that the global Orcinus orca taxon is inaccurate and that residents and transients do not belong to the same taxon, the decision not to list the Southern Residents cannot be based upon a lack of consensus in the field of taxonomy regarding the precise, formal taxonomic redefinition of killer whales, particularly when that lack of agreement is compounded by the extreme difficulty in gathering

> evidence to achieve consensus. The best available science standard gives "the benefit of the doubt to the species." Conner v. Burford, 848 F.2d 1441, 1454 (9th Cir.1988) (observing one of the purposes of the best available science standard in review of whether agency action may result in destruction or adverse modification of listed species' habitat pursuant to 16 U.S.C. § 1536(a)(2)). To deny listing of a species simply because one scientific field has not caught up with the knowledge in other fields does not give the benefit of the doubt to the species and fails to meet the best available science requirement.

*Id.* at 1239 (emphasis added).[22]

In response, Defendant Intervenors cite *Oceana, Inc. v.*

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[22] Plaintiffs cite another district court decision that applied the benefit of the doubt language: "To the extent that there is any uncertainty as to what constitutes the best scientific information, Congress intended for the agency to 'give the benefit of the doubt to the species.'" *Ctr. for Biological Diversity v. Bureau of Land Mgmt.*, 422 F. Supp. 2d 1115, 1127 (N.D. Cal. 2006)(citing *Conner*, 848 F.2d at 1454). However, that district court did not apply the "benefit of the doubt" concept in its analysis in any way, let alone as a presumption governing the agency's analysis of scientific information.

Another case Plaintiffs cite, *Rock Creek Alliance v. U.S. Fish & Wildlife Service*, 390 F. Supp. 2d 993, 1003 (D. Mont. 2005), does not support imposing a "benefit of the doubt" presumption to uncertain scientific evidence:

> Though the agency has discretion to make decisions based in its expertise, the ESA expresses a legislative mandate "to require agencies to afford first priority to the declared national policy of saving endangered species.... Congress has spoken in the plainest of words, making it abundantly clear that the balance has been struck in favor of affording endangered species the highest of priorities, thereby adopting a policy which it described as 'institutionalized caution.'"

*Id.* (quoting *Tennessee Valley Authority v. Hill*, 437 U.S. 153, 185 (1978)). However, as in *Center for Biological Diversity*, this language was part of a general discussion of the legal framework; the *Rock Creek* court never applied a benefit of the doubt presumption in the manner Plaintiffs suggest it should be applied here.





*Evans*, 384 F. Supp. 2d 203 (D.D.C. 2003), a challenge to NMFS's choice between two estimates of how much take a particular type of fishing gear would cause. The agency chose the lower estimate, reasoning that it was the "best estimate possible." The plaintiff argued that this estimate failed to give the "benefit of the doubt" to the species. *Id.* at 228. Although the lower estimate was uncertain, the district court reasoned that "the ESA does not require the agency to reject the 'best estimate possible' in favor of a more 'conservative' estimate that, according to the scientists, would be lacking in support." *Id.*

*Lohn* and *Oceana* appear irreconcilable, but, they can be harmonized. *Lohn* rejected an agency's decision to follow the taxonomy in the face of significant and compelling scientific evidence favoring a different conclusion. To side with the agency under such circumstances would "not give the benefit of the doubt to the species...." *Id.* at 1239. In contrast, *Oceana*, concerned an agency's choice of the "best estimate possible" over a more "conservative" estimate that lacked scientific support. The *Oceana* court refused to ignore the general rule that an agency must choose the best available science, simply because the ESA commands that the agency give the "benefit of the doubt" to the species. Both cases stand for the proposition that the agency must carefully examine the available scientific data and models and rationally choose the most reliable.

**2. The BiOp's Failure to Address the 2004 Fall Midwater Trawl Data.**

Plaintiffs assert that "one of the most egregious errors in the [BiOp] is its failure to consider available fall 2004 Delta

smelt abundance data, which evoked grave concern among agencies involved in smelt management."[23] (Doc. 232 at 5.) On February 9, 2005, FWS and other CALFED members met to discuss Delta smelt abundance. Among other things, participants discussed data from the 2004 fall midwater trawl ("FMWT") survey, which revealed that "estimates of Delta smelt appear to be their lowest since 1964." (Doc. 11 at 5; AR 9199-9200, 9202; Doc. 12.) The February 16, 2005, BiOp, contained no mention of the 2004 FMWT data.

Plaintiffs assert that FWS acted arbitrarily, capriciously and unlawfully by "ignoring" the 2004 FMWT data and relying instead on the more favorable abundance data from earlier abundance surveys. (AR 366-67 (noting that the 2003 FMWT results were more favorable than those from 2002, while simultaneously acknowledging that the 2003 summer townet index (1.6) was "well below the pre-decline average of 20.4 in (1959).").) Despite the receipt of the new, even less favorable 2004 FMWT data, FWS made no substantive changes to its jeopardy analysis in the biological opinion and did not use or address the new data in any way, not even to explain why the data was not discussed. At oral argument, the agency maintained that ESA analysis cannot go on forever, that there must be a cutoff.

Plaintiffs note that the low population numbers revealed by the FMWT data were "not unexpected," as smelt abundance had been on a downward trend for at least two years prior. (AR 370-71;

[23] Defendants and Defendant-Intervenors dispute whether the data "evoked grave concern." The degree of concern is irrelevant to the inquiry, as it is undisputed that the 2004 FMWT data showed the lowest smelt abundance on record.





9199-9200, 9202.) One prominent smelt biologist warned at a June 2003 OCAP symposium that managers should expect very low smelt abundance data in the near future and that water exports were a key factor in the population decline, noting that the "cumulative proportion of the population lost to exports relative to abundance" could be as high as 30 percent. (AR 5069.)

Federal Defendants suggest that Plaintiffs' entire argument should be rejected as internally inconsistent. (Doc. 242 at 26-27.) Plaintiffs contend that FWS should have revised the BiOp in light of the 2004 FMWT data and that additional evidence of a downward trend was "not unexpected." These contentions are consistent with the central premise of Plaintiffs' position -- that the 2004 FMWT data reflected a record low abundance (the data showed "estimates of Delta smelt appear to be at their lowest since 1964" (Doc. 11 at 5)); so low that the data should have been addressed in the BiOp, even if the agency already knew that smelt abundance was trending downward.

The State Water Contractors suggest that Plaintiffs' acknowledgment that the downward trend was "not unexpected," establishes that the BiOp fully recognizes the dire situation of the smelt. (Doc. 241 at 4.) The BiOp reflects that FWS had knowledge that smelt population levels were at extremely low levels, "[s]ince 1983, the delta smelt population has exhibited more low FMWT abundance indices, for more consecutive years, than previously recorded." (AR 367.)

> The results of seven surveys conducted by the Interagency Ecological Program (IEP) corroborate the dramatic decline in delta smelt....According to seven abundance indices designed to record trends in the status of the delta smelt, this species was

> consistently at low population levels during the last ten years (Stevens et al. 1990). These same indices also show a pronounced decline from historical levels of abundance (Stevens et al. 1990).

(AR at 370.) The State Water Contractors' argument ignores that the 2004 FMWT data evidences record low (the lowest) smelt abundance. Plaintiffs maintain that FWS' acknowledgment of a downward trend is inadequate as it does not address or analyze in survival and recovery terms, that smelt abundance levels had reached the lowest ever recorded.

The State Water Contractors argue that, although the BiOp admits the fact of the smelt's declining population, it does not and cannot explain the cause of the decline, because there is no scientific consensus as to causation. (Doc. 241 at 5.) "Contributing to [this] uncertainty," "is the fact that SWP and CVP operations have been ongoing for decades - a period during which Delta smelt abundance has increased as well as declined." (*Id.* at 6.) The State Water Contractors assert that the DSRAM was adopted in part to protect the smelt while further monitoring and research is carried out to resolve these uncertainties. They conclude that even if the 2004 FMWT data had been addressed in the BiOp, the ultimate opinion reached would not have differed; i.e., that operation of the projects under the 2004 OCAP BiOp would not jeopardize the smelt because, among other things, take will remain at or below historic levels and the DSRAM will protect smelt from salvage at project facilities.[24] But, this is

[24] The State Water Contractors maintain that CVP/SWP operations have been on-going for decades, during which time Delta smelt abundance has fluctuated greatly.





post hoc argument; neither the agency or the biological opinion addressed the 2004 FMWT data and available scientific information opined that Project operations contributed to the decline of the smelt.

The cases the parties cite do not answer whether FWS did not have to analyze most recent data because it would not have altered the ultimate conclusion. Some cases suggest that FWS must use all available information to ensure that a biological opinion analyzes the threats to a species in a comprehensive manner. Plaintiffs refer to *Greenpeace II,* 80 F. Supp. 2d at 1149-50, for the proposition that failure to analyze and incorporate available data is fatal to a biological opinion. In that case, NMFS concluded in a biological opinion that the total groundfish catch authorized in the Bering Sea and Gulf of Alaska in a single fishing season (1999) would not jeopardize the endangered Stellar sea lion. NMFS limited the scope of the biological opinion to that single year of fisheries management activities. The district court ruled that the agency should have broadened the scope of the biological opinion to consider the overall fishery management regime, including relevant regulations and specifications. *Id.* at 1146-47. This failure to produce a comprehensive biological opinion permeated all other aspects of the agency's decision. The district court found fault with the BiOp's superficial analysis, emphasizing the agency's failure to address the overall effects of the fisheries upon the sea lion:

> As far as the Court can ascertain, the focus of BiOp2 is limited to analyzing whether the fisheries compete with the sea lion for prey. In particular, BiOp2 focuses on the potential for localized depletions of prey caused by the fisheries. BiOp2 at 90, 112. Even

> with respect to this limited topic of discussion, meaningful analysis is virtually non-existent. NMFS itself repeatedly concludes in BiOp2 that it simply lacks the information to make any determination one way or the other. See BiOp2 at 111-118. Thus, NMFS's analysis is admittedly incomplete and its conclusions inconclusive. Although inconclusive data does not necessarily render a particular scientific conclusion invalid, the limited scope and quality of analysis that is contained in BiOp2 serves to highlight its overall inadequacy. For example, NMFS relies substantially on its conclusion that many of the target groundfish species are not important sea lion prey, despite uncertain evidence. BiOp2 at 114. That many of the target species may not individually constitute a major prey source, however, does not mean the cumulative impact of these fisheries is insignificant. In other words, limited analysis which suggests the fisheries do not jeopardize the sea lion does not obviate the requirement that NMFS address the full scope of the FMPs in order to ascertain their overall effects.
>
> In sum, BiOp2 is limited in scope, heavy on general background information, and deficient in focused and meaningful discussion and analysis of how these large fisheries, and the complex management measures which regulate them, affect endangered Steller sea lions. That NMFS now finds it necessary to undertake yet another "comprehensive consultation" is a final indication to this Court that BiOp2 is not the broad and in-depth consultation it was purported to be by NMFS, much less coextensive in scope with the FMPs as required under the ESA.
>
> A biological opinion which is not coextensive in scope with the identified agency action necessarily fails to consider important aspects of the problem and is, therefore, arbitrary and capricious. Here, BiOp2 not only fails to consider important aspects of the problem, the analysis it does contain is simply not adequate. Although an agency need not rely on conclusive scientific proof in a biological opinion, its conclusions must be based on "the best scientific and commercial data available." 16 U.S.C. § 1536(a)(2). Thus, an agency "cannot ignore available biological information or fail to develop projections" which may indicate potential conflicts between the proposed action and the preservation of endangered species. Conner, 848 F.2d at 1454.

*Id.* at 1149-50 (emphasis added).

In *Greenpeace II*, NMFS admitted that the information it needed to perform a more comprehensive review was available, but





argued that it "could not have been analyzed in the time allowed." *Id.* at 1150. The district court rejected this argument:

> A federal agency...is not "excused from [fulfilling the dictates of the ESA] if, in its judgment, there is insufficient information available to complete a comprehensive opinion and it takes upon itself [a more limited analysis]." Conner, 848 F.2d at 1455. This is not a situation where NMFS fully addressed the problem based on uncertain scientific data. *See Greenpeace Action v. Franklin*, 14 F.3d 1324, 1337 (9th Cir.1992). Rather, NMFS entirely ignored relevant factors and admittedly failed to analyze and develop projections based on information that was available.

*Id.* at 1150 (emphasis added); *see also Conner*, 848 F.2d at 1454 (biological opinion invalidated because agency failed to "use best information available to prepare comprehensive biological opinions considering all stages of agency action").

Plaintiffs analogize this case to *Greenpeace II*, because the agency has ignored available biological information. Here, Plaintiffs complain that FWS failed to incorporate into existing models and analyses that already reflected concern over an overall declining trend in smelt, the most recent survey information, evidencing a more pronounced decline in smelt populations than ever before recorded. In *Greenpeace II*, the agency entirely failed to perform a comprehensive review of threats to the sea lion. The difference in degree is not significant.

Federal Defendants cite *Oceana*, 384 F. Supp. 2d 203, where NMFS concluded that an amendment to the Atlantic Sea Scallop Fishery Management Plan would not jeopardize the protected loggerhead sea turtle, based on a population model that involved a degree of uncertainty, but that the agency determined was the

"most reliable method." *Id.* at 215. The *Oceana* plaintiffs did not dispute that the model represented the "best available science," instead arguing that the model was "so ill-suited to the purpose for which it was used, and so fraught with uncertainties," that the agency could not rationally reach its no jeopardy conclusion. *Id.* at 218. The district court upheld the agency's use of the model, reasoning "[t]ime and again courts have upheld agency action based on the 'best available' science, recognizing that some degree of speculation and uncertainty is inherent in agency decisionmaking, even in the precautionary context of the ESA." *Id.* at 219. Though the ESA should not be implemented "haphazardly, on the basis of speculation, *id.* at 219, the model "bears a rational relationship to the reality it purports to represent" and no other alternative model was available, *id.* at 221.

The circumstances here are not analogous to those in *Oceana*, where the plaintiffs admitted that the challenged model was the best, albeit uncertain, available science. Here, Plaintiffs maintain the agency's failure to analyze the most recent smelt population information prevented consideration of the best available, consequential scientific information.

Federal Defendants also rely on *Greenpeace I*, 14 F.3d at 1337, an earlier challenge to a Stellar sea lion biological opinion. The *Greenpeace I* plaintiffs argued that the agency acted arbitrarily and capriciously by approving certain fishery management measures despite uncertainty about the effects of the measures on the sea lion. The Ninth Circuit concluded that the presence of some uncertainty did not violate the best available





science requirement in part because that BiOp analyzed all the available data:

> We hold that the Service has fulfilled its substantive duties as well. Despite Greenpeace's assertions to the contrary, the Service supported its conclusions with ample data and analysis. The June biological opinion indicates that the Service, the Alaska Fisheries Science Center, and the National Marine Mammal Laboratory "analyzed all the available data on the pollock fishery and Steller sea lions" in the Gulf of Alaska. The Service also sought the recommendations of the Steller Sea Lion Recovery Team. The opinion demonstrates that the Service evaluated the spatial and temporal distribution of commercial fishing across the Gulf of Alaska. It then addressed not only the total biomass of pollock in the Gulf and the effects of fishery removals on that biomass, but also the spatial and temporal distribution of pollock across the Gulf. And despite Greenpeace's claims to the contrary, the Service did not ignore hydroacoustic surveys of pollock biomass, but considered and compared them to bottom trawl surveys. Finally, while the Service has repeatedly conceded that it was uncertain about the effectiveness of its management measures, it premised these measures on a reasonable evaluation of available data, not on pure speculation.
>
> The biological opinions indicate that the Service, an expert agency, consulted with other teams of experts to consider all relevant factors pertaining to the effects of the Gulf fishery on the Steller sea lion. And they indicate that the Service did not ignore data, as Greenpeace suggests. The Service's decision to go ahead with the 1991 fishery under the proposed restrictions, despite some uncertainty about the effects of commercial pollock fishing on the Steller sea lion, was not a clear error of judgment.

(Emphasis added.) *Id.* at 1337. Here, unlike *Greenpeace I*, FWS failed to analyze all of the available data on the Delta smelt, as the 2004 FMWT data is not mentioned in the BiOp. Nor has FWS resolved uncertainties about the identified causes of the serious decline in Delta smelt abundance by adopting unenforceable management measures.

"Although a decision of less than ideal clarity may be upheld if the agency's path may reasonably be discerned, [a

court] cannot infer an agency's reasoning from mere silence. Rather, an agency's action must be upheld, if at all, on the basis articulated by the agency itself." *Pacific Coast Fed'n of Fishermen's Ass'ns v. United States Bureau of Reclamation*, 426 F.3d 1082, 1091 (9th Cir. 2005)(internal citations and quotations omitted). "[W]hen reviewing a biological opinion, [a court may] rely only 'on what the agency actually said'...." *Id.* (quoting *Gifford Pinchot Task Force*, 378 F.3d at 1072 & n. 9). Had FWS examined the FMWT 2004 data in the BiOp, the weight it gave to that data would have been entitled to deference. The agency's silence cannot be afforded deference.

a. **The timing of the 2004 FMWT Data relative to the issuance of the BiOp.**

Federal Defendants complain the timing of the release of the 2004 FMWT data did not leave enough time to address the data before issuance of the biological opinion. The record shows at the very latest, the 2004 FMWT data was presented to FWS and other CALFED members on February 9, 2005, less than a week before the February 16, 2005, issuance of the biological opinion. Federal Defendants assert they were not required to rewrite the BiOp at the "eleventh hour." (Doc. 242 at 27).

Although the record shows the 2004 FMWT data was presented at the February 9, 2005 CALFED meeting, it is unclear when FWS first saw this data. Plaintiffs' claim that the data was available in December 2004, is not supported.[25] However, even assuming FWS was not aware of the 2004 FMWT data until February

[25] Plaintiffs' record citations, AR 9199--9202, are print-outs of the FMWT data which post date the issuance of the BiOp.





9, 2005, the agency was not operating under a deadline. As in *Greenpeace II*, where the agency's statutory duty was not excused because the data could not be "analyzed in the time allowed," 80 F. Supp. 2d at 1150, here, FWS could have delayed releasing the biological opinion until it had reviewed and analyzed the new abundance data, which was especially significant as it showed Delta smelt abundance at its nadir.

Defendants and Defendant-Intervenors rejoin that the failure of the BiOp to directly address the 2004 FMWT is harmless, because one of the DSRAM's trigger criteria is an index based upon the previous years' FMWT results, calling for any new abundance data to be incorporated into the adaptive management process. However, even if the data were considered later in the DSRAM process, no designated protective actions are required to be taken in response to any of the triggering criteria.[26]

Federal Defendants raise a legitimate concern about having to prolong completion of the BiOp on the eve of its release. In theory, new scientific information could arrive on FWS's doorstep on a daily basis. If FWS was required to consider and address every new piece of information it received prior to publication of its decision, it would be effectively impossible for the

[26] Abundance data is relevant to aspects of the BiOp that are independent of the DSRAM process. For example, the agency's conclusion that the level of anticipated take "is not likely to result in jeopardy to the smelt because this level of take is at or below historical levels of take" (AR 474), is irrational because no consideration is given to the current decline in smelt abundance nor any explanation provided how the further decline of the smelt does not exacerbate jeopardy to the species' survival and recovery.

agency to complete a biological opinion. But, this is not such a case. The FMWT is a credible and reliable Delta smelt population abundance survey, regularly compiled on an annual basis, and relied upon by the agency in the past. There is no rational reason to ignore such important data. The BiOp places great weight on the FMWT as "the second longest running survey." (AR 366, 370). The agency does not suggest the time of receipt of the 2004 FMWT data was unexpected. The agency's failure to acknowledge and analyze the record low abundance levels revealed by the 2004 FMWT is unreasonable and violated its duty to use the best available scientific information. 16 U.S.C. § 1536(a)(2).

Plaintiffs' motion for summary adjudication is **GRANTED** as to this claim.

**3. Global Climate Change Evidence.**

Plaintiffs next argue that the BiOp ignored data about Global Climate Change that will adversely affect the Delta smelt and its habitat. (Doc. 232 at 7.) This is potentially significant because the BiOp's conclusions are based in part on the assumption that the hydrology of the water bodies affected by the OCAP will follow historical patterns for the next 20 years. (AR 375 (explaining that CALSIM II modeling involved making "adjustments to historic water supplies...by imposing future level land use on historical meteorological and hydrologic conditions").)

In a July 28, 2004 comment letter, Plaintiff NRDC directed FWS's attention to several studies on the potential effects of climate change on water supply reliability, urging that the issue be considered in the BiOp. (AR 8552-56.) The comment letter





stated:

> The best scientific data available today establishes that global climate change is occurring and will affect western hydrology. At least half a dozen models predict warming in the western United States of several degrees Celsius over the next 100 years (Redmond, 2003). Such sophisticated regional climate models must be considered as part of the FWS' consideration of the best available scientific data.
>
> Unfortunately, the Biological Assessment provided by the Bureau to FWS entirely ignores global climate change and existing climate change models. Instead, the BA projects future project impacts in explicit reliance on seventy-two years of historical records. In effect, the Biological Assessment assumes that neither climate nor hydrology will change. This assumption is not supportable.
>
> In California, a significant percentage of annual precipitation falls as snow in the high Sierra Nevada mountains. Snowpack acts as a form of water storage by melting to release water later in the spring and early summer months (Minton, 2001). The effects of global climate change are expected to have a profound effect on this dynamic. <u>Among other things, more precipitation will occur as rain rather than snow, less water will be released slowly from snowpack "storage" during spring and summer months, and flooding is expected to increase</u> (Wilkinson, 2002; Dettinger, 2003). <u>These developments will make it more difficult to fill the large reservoirs in most years, reducing reservoir yields and will magnify the effect of CVP operations on downstream fishes</u> (Roos, 2001). These developments will also dramatically increase the cost of surface storage relative to other water supply options, such as conservation.
>
> While the precise magnitude of these changes remains uncertain, judgments about the likely range of impacts can and have been made. *See e.g.*, U.S. Global Climate Action Report - 2002; Third National Communication of the United States Under the United Nations Framework Convention on Climate Change at 82, 101 (2002). [FN3]. The Service can and must evaluate how that range of likely impacts would affect CVP operations and impacts, including the Bureau's ability to provide water to contractors while complying with environmental standards. We therefore request that the Service review and consider the work cited above, as well as the background and Dettinger presentation at a recent climate change conference held in Sacramento, June 9-11, 2004 [citation omitted] and climate change reports [citation omitted].

(AR at 8554-55 (emphasis added).)

A second presentation by Michael Dettinger at a December 8-9, 2004 CALFED meeting, attended by FWS staff, concluded that "warming is already underway..."; that this would result in earlier flows, more floods, and drier summers; and that "California water supplies/ecosystems are likely to experience [] changes earliest and most intensely." (Doc. 10 at 18.) Following Dettinger's presentation, members of CALFED noted "the need to reevaluate water storage policies and ERP [Ecosystem Recovery Program] recovery strategies, all of which would be affected by projected climate changes." (Doc. 9 at 3.) The record reflects that extreme water temperatures can have dramatic impacts upon smelt abundance. (AR 8979-80.)

In addition to the specific studies and data cited by NRDC, FWS scientists recognized the issue of climate change warranted further consideration. At a June 2003 symposium entitled "Framing the issues for Environmental and Ecological Effects of Proposed Changes in Water Operations: Science Symposium on the State of Knowledge," a number of questions regarding climate change were raised, including: "How does the proposed operations plan account for the potential effects of climate change (e.g., El Nino or La Nina, long term changes in precipitation and runoff patters, or increases in water temperature)?" (AR at 4839.)

Plaintiffs argue that, despite this evidence that climate change could seriously impact the smelt by changing Delta hydrology and temperature, the BiOp "did not so much as mention the probable effects of climate change on the delta smelt, its habitat, or the magnitude of impacts that could be expected from





the 2004 OCAP operations, much less analyze those effects." (Doc. 232 at 8.) Defendants and Defendant-Intervenors respond by arguing (1) that the evidence before FWS at the time the BiOp was issued was inconclusive about the impacts of climate change; and (2) that, far from ignoring climate change, the issue is built into the BiOp's analysis through the use of X2 as a proxy for the location and distribution of Delta smelt.

a. ***Inconclusive Nature of Available Information Regarding the Impacts of Global Climate Change on Precipitation.***

Federal Defendants and the State Water Contractors characterize Mr. Dettinger's presentation, as reflecting "a great deal of uncertainty that climate change will impact future precipitation." The presentation is entitled "Climate Change Uncertainties and CALFED Planning." (Doc. 10 at 1.) Dettinger acknowledges that, although current climate models "yield consistent warming scenarios for California" (*id.* at 6), there is no similar consensus regarding the impact of warming on future precipitation (*id.* at 7). Federal Defendants suggest that FWS "responsibly refused to engage in sheer guesswork, and properly declined to speculate as to how global warming might affect delta smelt." (Doc. 242 at 23.) But, the NRDC letter cited a number of studies in addition to Mr. Dettinger's presentations, all of which predict that anticipated climate change will adversely impact future water availability in the Western United States.

At the very least, these studies suggest that climate change will be an "important aspect of the problem" meriting analysis in the BiOp. *Pacific Coast Fed'n*, 265 F.3d at 1034. However, as with the 2004 FMWT data, the climate change issue was not

meaningfully discussed in the biological opinion, making it impossible to determine whether the information was rationally discounted because of its inconclusive nature, or arbitrarily ignored.[27]

b. ***X2 as a Proxy for Climate Change.***

The State Water Contractors argue that the approaches taken in the DSRAM are "more than adequate to deal with the projected impacts of climate change - assuming they occur." (Doc. 241 at 8.) For example, Plaintiffs' suggestion that climate change will produce earlier flows, more floods, and drier summers is addressed by the DSRAM's X2 trigger. Flow level changes will be

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[27] Plaintiffs argue that "[r]egardless of the uncertainty involved in predicting the consequences of climate change, FWS had an obligation under the ESA to address the probable effects on Delta smelt." (Doc. 232 at 7.) In response, the State Water Contractors quote the following passage from *Bennett v. Spear*, 520 U.S. 154, 176-177 (1997), in support of the proposition that the ESA intended to preclude exactly this kind of argument:

> The obvious purpose of the requirement that each agency "use the best scientific and commercial data available" is to ensure that the ESA not be implemented haphazardly, on the basis of speculation or surmise. While this no doubt serves to advance the ESA's overall goal of species preservation, we think it readily apparent that another objective (if not indeed the primary one) is to avoid needless economic dislocation produced by agency officials zealously but unintelligently pursuing their environmental objectives.

But, this passage from *Bennet* was part of a broader discussion holding that persons who are economically burdened by a decision made under the ESA fall within the zone of interests the statute protects for the purposes of standing. *Bennet* sheds little light on the current inquiry -- whether and to what extent the data that was before the FWS regarding climate change should have been considered and addressed in the BiOp.





reflected in the position of X2. If climate change alters water temperatures, DSRAM also includes a temperature trigger, that monitors the temperature range within which successful Delta smelt spawning occurs.

The DSRAM offers no assurance that any mitigating fish protection actions will be implemented if the X2 criteria is triggered. That X2 indirectly monitors climate change does not assuage Plaintiffs' concerns that the BiOp has not adequately analyzed the potential impact of climate change on the smelt.

The BiOp does not gauge the potential effect of various climate change scenarios on Delta hydrology. Assuming, *arguendo*, a lawful adaptive management approach, there is no discussion when and how climate change impacts will be addressed, whether existing take limits will remain, and the probable impacts on CVP-SWP operations.

FWS acted arbitrarily and capriciously by failing to address the issue of climate change in the BiOp. This absence of <u>any</u> discussion in the BiOp of how to deal with any climate change is a failure to analyze a potentially "important aspect of the problem."[28]

Plaintiffs' motion for summary adjudication is **GRANTED** as to this claim.

D. **<u>There is No Rational Connection Between the No Jeopardy Finding and the Status of the Species</u>**.

Plaintiffs next allege that there is no rational connection

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[28] There is no basis to determine what weight FWS should ultimately give the climate change issue in its analysis.

between the record evidence and the BiOp's "no jeopardy" conclusion. Plaintiffs first argue that the BiOp's approach to setting take limits is arbitrary and capricious because FWS failed to consider defined take limits in the context of current smelt abundance. Plaintiffs complain that the BiOp does not explain how its no jeopardy conclusion can be justified in light of the admitted adverse effects of the project, along with indirect and cumulative effects on the species.

In a formal consultation, the ESA requires FWS to "[f]ormulate its biological opinion as to whether the action, taken together with cumulative effects, is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat." 50 C.F.R. § 402.14; *see also* 16 U.S.C. § 1536(a)(2). The phrase "jeopardize the continued existence of" means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. § 402.02.

Agency action may be overturned if the agency has "relied on factors which Congress has not intended it to consider, entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise." *Pacific Coast Fed'n*, 265 F.3d at 1034. A court must ask "whether the agency considered the relevant factors and





articulated a rational connection between the facts found and the choice made." *Id.* The agency must "examine the relevant data and articulate a satisfactory explanation for its action including a rational connection between the facts found and the choice made." *Motor Vehicle Mfrs. Ass'n v. State Farm Mutual Ins.*, 463 U.S. 29, 43 (1983).

**1. Plaintiffs' Argument that Salvage Underestimates Project Impacts on the Smelt.**

Plaintiffs assert that the BiOp's reliance on salvage is arbitrary and capricious because salvage is not a reliable basis for setting Project take limits. Plaintiffs cite record evidence, including statements made by smelt biologists and FWS employees, that salvage does not accurately estimate incidental take of young Delta smelt. (*See* AR 8403, 7578.) The BiOp admits that salvages does not fully account for all smelt losses. (AR 419 ("It should be noted that although salvage is used to index delta smelt take, it does not reliably index delta smelt entrainment. Furthermore, delta smelt salvage is highly variable at all time scales....).") Plaintiffs have not shown that a better measure of smelt take could have been generated from available data. The agency is entitled to rely on this approach as it appears to be the "best estimate possible," no party has suggested an alternative. *See Oceana*, 384 F. Supp. 2d at 228.

This objection standing alone is insufficient to justify summary adjudication.

**2. The BiOp's Approach to Estimating Future Take Without Considering the Smelt's Current Abundance Is Arbitrary and Capricious.**

The take limits are based on historic sampling from "salvage

density" (number of fish taken per unit of water), which data is adjusted using CALSIM II modeling to reflect water flows anticipated under the circumstances of the final consultation. FWS's no jeopardy determination is based in part on flow modeling for the final consultation scenario that predicted lower than historic salvage levels during critical times. (AR 474 (finding that the level of anticipated take "is not likely to result in jeopardy to the smelt because this level of take is at or below historical levels of take.")

A close examination of the administrative record reveals that this conclusion relies upon an unsupported irrational assumption not justified by the record, i.e., that maintaining salvage at or below historic salvage levels will ensure that the 2004 OCAP is not likely to jeopardize the continued existence of the Delta smelt. First, by focusing only on how proposed operations will either increase or decrease smelt take, FWS effectively limited its analysis to determining whether the magnitude of the OCAP's impact upon the smelt would be different from the Projects' impact under the regulatory historical baseline. FWS did not analyze how the absolute number of smelt taken during any given period of Project operations will impact overall smelt abundance at the time of the 2005 BiOp or in the future. Nor does the finding the smelt "still persists," even at the lowest recorded abundance levels, have any meaning if the smelt's "persistence" is at a level at or near extinction. Evaluating "persistence" instead of smelt population abundance is irrational, arbitrary, and runs counter to the evidence before the agency.





The Ninth Circuit, in *NWF v. NMFS*, 481 F.3d 1224 at *8, invalidated a biological opinion in part because it failed to view the agency action "in the present and future human and natural contexts." Here, the BiOp similarly fails to provide a scientific explanation for why it is appropriate to set incidental take without considering the most current smelt population data. This methodology fails to take most recent available natural conditions (i.e., the smelt's current and/or future population abundance) into consideration. For example, if the smelt's population is currently 600,000, it might be justifiable to permit a monthly take of over 30,000. However, if the smelt's current population is only 60,000, allowing 30,000 to be entrained in the pumps in a single month would represent a 50% reduction in smelt population. Even if the 30,000 figure was significantly lower than historic take, Defendant-Intervenors agree "that salvage impacts cannot be accurately identified without a population estimate." (Doc. 247 at 9 n.13.)

DWR asserts that, in setting the take limits, the BiOp took into consideration concerns expressed by experts that using historic information alone would not create an appropriate take limit. (*See* AR 4880, 5532, 5543). The first of the citations offered by DWR, an email sent by FWS's Wim Kimmerer to several individuals at DWR, EPA and elsewhere, states that there was some discussion at FWS about "getting away from take as the principle criterion governing management and recovery of delta smelt." (AR 4880.) The next page of this email goes on to admit that "determining what level of mortality is acceptable or 'safe' is going to be difficult... Ultimately...this should be done through

some sort of population model or viability analysis." (AR 4881 (emphasis added).) The other cited communications express similar concerns. (*See* AR 5532, 5543.) It is time to do it, yet FWS continues to profess the smelt population cannot be reliably measured.

DWR argues that, together, the take limits and the DSRAM address these concerns by moving the focus of management away from salvage. However, there is no way to know when or what measures will be taken under the DSRAM, which leaves the existing take limits as the only enforceable measures in the BiOp,[29] while the species heads toward extinction. Using flawed take limits and refusing to quantify smelt population and recent viability trends create substantial doubt about the reliability of the BiOp.

Defendants and Defendant-Intervenors suggest that sufficient information was simply not available to accurately determine smelt abundance.[30] Plaintiffs rejoin by referring to an email

[29] There is no recognized mechanism for introducing any population viability data, collected through the adaptive management process, into the setting of the take limits.

[30] The San Luis Parties mischaracterize Plaintiffs argument as a request for FWS to undertake additional research projects. (Doc. 247.) Defendant Intervenors are correct that FWS is not required to undertake new research, *Greenpeace Action v. Franklin*, 14 F.3d 1324, 1335 (9th Cir. 1992)(agency may proceed despite uncertainty about accuracy of modeling effort); Southwest Ctr for Biological Diversity, 215 F. 3d 58, 60 (D.C. Cir. 2000)(agency could rely on inconclusive data to make decision; not obligated to conduct new independent studies). Plaintiffs do point out that FWS acknowledges in the AR that an accurate determination of non-jeopardy would require knowledge of how many smelt existed, what proportion would be lost due to the projects, and what level of loss would be sustainable. (Doc. 232





sent by Zachary Hymanson to Ryan Olah at FWS, with copies to others at concerned federal and state agencies. Mr. Hymanson opined: "I think we are at the point where we should report and use quantified estimates of the total number of individuals at the various life stages monitories. Quantified population and life stage estimates of fishes around the world are routinely made with A LOT less data than we have for delta smelt." (AR 7542 (emphasis in original).)

The viability of Delta smelt has been under scrutiny for over ten years. No party has shown that producing a reliable population estimate is scientifically unfeasible. Information does not have to be perfect or infallible for the agency to be required to use it to create a population estimate. *See Greenpeace II*, 80 F. Supp. 2d at 1149-50 (finding it unlawful for agency to entirely ignore relevant factor and fail to analyze and develop projections regarding that factor based on information that was available); *see also Conner*, 848 F.2d at 1454 (biological opinion invalidated because agency failed to "use best information available to prepare comprehensive biological opinions considering all stages of agency action."). Without population estimates, it is arbitrary for the agency to conclude that project operations will not result in jeopardy simply because the projects will take relatively fewer smelt than they did in the past, in the face of the undisputed fact that the

at 23 (citing AR 8221).) However, the crux of Plaintiffs' concern is that FWS has not developed such population data and ignored important existing data on abundance in setting the take limits.

smelt population has been declining steadily in recent years. Failing to incorporate any information about smelt population abundance into the setting of the take limits is a fundamental failure rendering the BiOp arbitrary and capricious.

The San Luis Parties' rationalization of FWS's approach, setting the incidental take limits using a model that does not take current abundance data into consideration, is that historic records reveal "either no, or perhaps a very weak relationship, between juvenile abundance measured by the TNS and adult abundance measured by the FMWT." (Doc. 247 at 5.) This "lack of [a] linear relationship between the two indices, shows that events after the TNS, in late summer and early fall, are probably affecting the number of juveniles that mature into spawners." (Doc. 247 at 6.) From the lack of a linear relationship, San Luis infers that something other than salvage (i.e. entrainment in the pumps) is causing the smelt's decline.[31]

The BiOp interprets the data differently:

[31] The Administrative Record reflects various explanations for the lack of a linear relationship between the TNS and the FMWT. (AR 1025-26.) One possible explanation for why the number of spawning age smelt (indexed by the FMWT) seems to be a poor predictor of subsequent offspring (indexed by the TNS) is that there is some environmental factor (not directly related to entrainment at the projects) limiting survivability, inferring that there is a carrying capacity for the population. (*Id.*) Alternatively, some scientists question whether it is proper to try to draw statistical conclusions from the entire 1969-2002 data pool, given that the smelt experienced a precipitous decline in 1981. These scientists have postulated that the data "may reflect two different relationships from two time periods with different delta smelt carrying capacities." (*Id.* at 1026.) One study cited in the AR indicates that food supply may be the limiting factor during this time period. (AR 8976.)





> In a near-annual fish like delta smelt, a strong relationship would be expected between number of spawners present in one year and number of recruits to the population the following year. Instead, the stock-recruit relationship for delta smelt is weak, accounting for about a quarter of the variability in recruitment (Sweetnam and Stevens 1993). <u>This relationship does indicate, however, that factors affecting numbers of spawning adults</u> (e.g., <u>entrainment</u>, toxics, and predation) <u>can have an effect on delta smelt numbers the following year</u>.

(AR at 364 (emphasis added).)[32] Plaintiffs refer to other record evidence creating doubt that salvage is not a statistically reliable indicator of smelt abundance, including high entrainment events in the early 1980s and other "extreme events," including the El Niño of 1982-83, which caused significant declines in smelt abundance. (AR 8979.)

The BiOp acknowledges that salvage can have an impact on smelt abundance (although the statistical relationship is non-linear). It is arbitrary and capricious for FWS to base take limits on a projection of future salvage calculated without considering the most current or future smelt abundance and without reliable smelt population estimate.

Plaintiffs' motion for summary adjudication is **GRANTED** as to this issue. The BiOp's approach to setting incidental take limits is arbitrary and capricious because it fails to incorporate reliable smelt population data and the most recent

[32] The San Luis Parties raise numerous questions regarding FWS's conclusion that there is a statistical relationship between the numbers of spawning adults and Delta smelt abundance the following year, criticizing the statistical analyses referenced in the BiOp. (Doc. 247 at 5.) It is unnecessary to adjudicate these issues, as the San Luis Parties have not separately challenged the conclusions reached in the BiOp on this ground nor have they moved for summary judgment on any issue in this case.

information regarding smelt abundance.

**3. Plaintiffs' Argument That the Biop Fails to Explain How its No Jeopardy Conclusion Can Be Justified in Light of the Identified Adverse Effects of the Project, along with Indirect and Cumulative Effects.**

In formulating a biological opinion, the ESA requires FWS to determine "whether the action, taken together with cumulative effects, is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat." 50 C.F.R. § 402.14 (emphasis added). "Jeopardize the continued existence of" means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. § 402.02 (emphasis added).

The BiOp concludes that the 2004 OCAP will have numerous direct and indirect impacts apart from salvage, including habitat loss, increased vulnerability of Delta smelt to predation, and increased vulnerability to adverse temperature effects. (*See* AR 399, 443-44.) Plaintiffs allege that, although the BiOp lists indirect impacts, it fails to explain how they relate to the potential for jeopardy.

Federal Defendants respond to this allegation with a single paragraph, asserting generally that "the biological opinion considers the effects of dozens of project components, each with a multi-layered analysis," and indicating how many times the topics of predation (18), temperature changes (180 references), life cycle impacts (75 references to the term "juveniles") are





discussed in the BiOp. (Doc. 242 at 30.) What Federal Defendants do not do is point to those portions of the BiOp which analyze these issues in a way that demonstrates why these indirect impacts will not cause jeopardy or how they relate to survival and recovery of the smelt. A review of the BiOp does not reveal such an analysis.

The State Water Contractors suggest that the DSRAM trigger criteria were designed to address all of the potential impacts identified in the BiOp. (Doc. 241 at 8.) This leaves for future consideration and speculation the impacts events activating DSRAM triggers will have.

**a. *Cumulative Impacts.***

Plaintiffs also argue that the BiOp fails to meaningfully address cumulative impacts, "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." 50 C.F.R. § 402.02. The BiOp highlights a number of predicted cumulative effects:

> Any continuing or future non-Federal diversions of water that may entrain adult or larval fish would have cumulative effects to the smelt. Water diversions through intakes serving numerous small, private agricultural lands contribute to these cumulative effects. These diversions also include municipal and industrial uses. State or local levee maintenance may also destroy or adversely modify spawning or rearing habitat and interfere with natural long term habitat-maintaining processes.
>
> Additional cumulative effects result from the impacts of point and non-point source chemical contaminant discharges. These contaminants include but are not limited to selenium and numerous pesticides and herbicides as well as oil and gasoline products associated with discharges related to agricultural and urban activities. Implicated as potential sources of mortality for smelt, these contaminants may adversely

> affect fish reproductive success and survival rates. Spawning habitat may also be affected if submersed aquatic plants, used a[s] substrates for adhesive egg attachment, are lost due to toxic substances.
>
> Other cumulative effects could include: the dumping of domestic and industrial garbage may present hazards to the fish because they could become trapped in the debris, injure themselves, or ingest the debris; golf courses reduce habitat and introduce pesticides and herbicides into the environment; oil and gas development and production remove habitat and may introduce pollutants into the water; agricultural uses on levees reduce riparian and wetland habitats; and grazing activities may degrade or reduce suitable habitat, which could reduce vegetation in or near waterways.

(AR 468.) There is no quantitative and qualitative analysis of the potential impact of these cumulative effects on the smelt and its habitat, except to identify the causes, the BiOp concludes without explanation, "[t]he cumulative effects of the proposed action [are] not expected to alter the magnitude of cumulative effects on the above described actions upon the critical habitat's conservation function for the smelt." (*Id.*)

The San Luis Parties argue that FWS's no jeopardy conclusion and impacts analysis is "rationally based on its determination that the proposed future changes will not significantly increase the magnitude of the ongoing Project's potential impacts." (Doc. 247 at 9.) This conclusion is the kind of analysis recently rejected by the Ninth Circuit in *NWF v. NMFS*:

> To "jeopardize the continued existence of" means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 CFR § 402.02; 16 U.S.C. § 1536(a)(2). NMFS argues that, under this definition, it may satisfy the ESA by comparing the effects of proposed FCRPS operations on listed species to the risk posed by baseline conditions. Only if those effects are





> "appreciably" worse than baseline conditions must a full jeopardy analysis be made. Under this approach, a listed species could be gradually destroyed, so long as each step on the path to destruction is sufficiently modest. This type of slow slide into oblivion is one of the very ills the ESA seeks to prevent.
>
> Requiring NMFS to consider the proposed FCRPS operations in their actual context does not, as NMFS argues, effectively expand the "agency action" at issue to include all independent or baseline harms to listed species. Nor does it have the effect of preventing any federal action once background conditions place a species in jeopardy. To "jeopardize"--the action ESA prohibits--means to "expose to loss or injury" or to "imperil." Either of these implies causation, and thus some new risk of harm. Likewise, the suffix "-ize" in "jeopardize" indicates some active change of status: an agency may not "cause [a species] to be or to become" in a state of jeopardy or "subject [a species] to" jeopardy. American Heritage Dictionary of the English Language (4th ed.). Agency action can only "jeopardize" a species' existence if that agency action causes some deterioration in the species' pre-action condition.
>
> Even under the so-called aggregation approach NMFS challenges, then, an agency only "jeopardize[s]" a species if it causes some new jeopardy. An agency may still take action that removes a species from jeopardy entirely, or that lessens the degree of jeopardy. <u>However, an agency may not take action that will tip a species from a state of precarious survival into a state of likely extinction</u>. <u>Likewise, even where baseline conditions already jeopardize a species, an agency may not take action that deepens the jeopardy by causing additional harm</u>.
>
> Our approach does not require NMFS to include the entire environmental baseline in the "agency action" subject to review. It simply requires that NMFS appropriately consider the effects of its actions "within the context of other existing human activities that impact the listed species." *ALCOA*, 175 F.3d at 1162 n. 6 (citing 50 C.F.R. § 402.02's definition of the environmental baseline). <u>This approach is consistent with our instruction (which NMFS does not challenge) that "[t]he proper baseline analysis is not the proportional share of responsibility the federal agency bears for the decline in the species, but what jeopardy might result from the agency's proposed actions in the present and future human and natural contexts</u>." *Pac. Coast Fed'n*, 426 F.3d at 1093 (emphasis added).

481 F.3d 1224 at *7-8 (emphasis added)(footnote omitted).

Here, the BiOp does not consider the cumulative effects of any future DSRAM actions, which it relies on to avoid jeopardy, nor does it meaningfully relate the most current abundance of the species to future OCAP operations to assess jeopardy. The BiOp unlawfully fails to adequately analyze indirect and cumulative impacts of the 2004 OCAP. Summary adjudication on this issue is appropriate.

**E. Did the BiOp Fail to Adequately Consider Impacts to Critical Habitat?**

Plaintiffs allege that the BiOp fails to adequately consider critical habitat in two respects. First, by failing to analyze the impacts of the 2004 OCAP on the value of critical habitat for the recovery as opposed to just the survival of the smelt. Second, failure to consider impacts to all of the Delta smelt's critical habitat because it focuses only on X2.

**1. Did the BiOp Fail to Consider Whether 2004 OCAP Would Diminish Value of Critical Habitat for Recovery?**

The ESA requires FWS to determine whether the 2004 OCAP will destroy or adversely affect Delta smelt critical habitat. 16 U.S.C. § 1536(a)(2). "Destruction or adverse modification of critical habitat" means "a direct or indirect alteration that appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical." 50 C.F.R. § 402.02

Initially, the critical habitat analysis was conducted





pursuant to agency regulations that defined adverse modification as:

> [A] direct or indirect alteration that appreciably diminishes the value of critical habitat for **both survival and recovery** of a listed species. Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical.

50 C.F.R. § 402.02 (emphasis added).

Following the issuance of the 2004 BiOp, the Ninth Circuit invalidated the adverse modification regulation, based on its own interpretation of the regulation's language, "alteration that appreciably diminish the value of critical habitat for both the survival and recovery of a listed species," "reads the 'recovery' goal out of the adverse modification inquiry." *Gifford Pinchot*, 378 F.3d at 1069-70.

The Bureau requested that FWS reinitiate consultation on the 2004 OCAP to ensure compliance with *Gifford Pinchot*. The result was the disputed 2005 BiOp, which expressly states that it does not rely on the invalidated regulation. (AR 248.) Rather, the BiOp "relied on the statutory provisions of the ESA to complete the analysis with respect to critical habitat." (*Id.*) The ESA defines critical habitat as including "the specific areas ... occupied by the species ... which are ... essential to the conservation of the species" and the "specific areas outside the geographical area occupied by the species ... that ... are essential for the conservation of the species...." 16 U.S.C. § 1532(5)(A). This statutory reference to "conservation" was the premise for the Ninth Circuit's *Gifford Pinchot* reasoning:

> "Conservation" is a much broader concept than mere

> survival. The ESA's definition of "conservation" speaks to the recovery of a threatened or endangered species. Indeed, in a different section of the ESA, the statute distinguishes between "conservation" and "survival." Requiring consultation only where an action affects the value of critical habitat to both the recovery and survival of a species imposes a higher threshold than the statutory language permits

378 F.3d at 1070 (internal citation omitted).

The 2005 BiOp uses the term "conservation," rather than "survival" and/or "recovery," several times in connection with its critical habitat analysis. In the "Critical Habitat Effects" section, the BiOp states that the "primary constituent elements essential to conservation of the species will not be affected by the proposed project." (AR 423.) In addition, after discussing critical habitat, including those areas essential to spawning, transport, rearing and migration, the BiOp acknowledges impacts, but explains that after the proposed diversions in the OCAP are implemented "the primary constituent elements [of critical habitat] essential to the conservation of the species still function." (*Id.* at 371.)[33] What specific effects any DSRAM

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[33] Defendant-Intervenors argue that, because of these mentions of "conservation," FWS is entitled to a "presumption of regularity," and the court must assume that agency considered recovery. (Doc. 247 at 12.) In *Gifford Pinchot*, after invalidating the destruction and adverse modification regulation, the Ninth Circuit considered whether it should presume that the agency followed its own regulation that was valid at the time the biological opinion was issued. The Ninth Circuit concluded that, because the agencies must be afforded a "presumption of regularity," a court must assume that the agency followed the then applicable regulation. *Id.* at 1072. Applying this presumption here, given that the agency specifically applied the statute, not the invalid regulation, there is no evidence the agency applied an invalid regulation. However, Defendant-Intervenors' suggestion that the presumption should be applied to validate the BiOp's analysis of recovery is misplaced. The





measures will have on the smelt are not described, nor is there discussion of how the survival and recovery of the smelt will be accomplished.

The Ninth circuit explained in *NWF v. NFMS*, that the agency must conduct a "full analysis" of risks to recovery.

> The question before us is not whether, on the merits, recovery risks in fact require a jeopardy finding here, but whether, as part of the consultation process, NMFS must conduct a **full analysis** of those risks and their impacts on the listed species' continued existence. Although recovery impacts alone may not often prompt a jeopardy finding, NMFS's analytical omission here may not be dismissed as harmless: the highly precarious status of the listed fishes at issue raises a substantial possibility that considering recovery impacts could change the jeopardy analysis. The only reasonable interpretation of the jeopardy regulation requires NMFS to consider recovery impacts as well as survival.

481 F.3d 1224 at *9-*10 (emphasis added).[34]

Plaintiffs claim that although the BiOp includes generic promises to consider recovery of the smelt, it does not competently analyze nor provide for recovery. Federal Defendants and Defendant Intervenors respond that the BiOp's discussion of critical habitat effects, in conjunction with the BiOp's conclusion that "the smelt's primary constituent elements essential to the conservation of the species [will] still

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agency still has an obligation to thoroughly consider the issue of recovery and to reach a reasoned conclusion based on the evidence in the administrative record.

[34] Although this portion of *NWF v. NMFS* concerned analysis of recovery in the context of the "no jeopardy" determination, as opposed to the "destruction or adverse modification of critical habitat" analysis, the holding is equally applicable to habitat jeopardy.

function" (AR 371) under the 2004 OCAP, is a sufficient analysis of the impacts on recovery.

The BiOp's overarching conclusion is that "the smelt's primary constituent elements essential to the conservation of the species [will] still function." In designating critical habitat for a listed species, FWS must "consider those physical and biological features that are essential to the conservation of [the] species and that may require special management considerations or protection." 50 C.F.R. § 424.12. The features that must be considered include, but are not limited to, the following:

> 1. Space for individual and population growth, and for normal behavior;
>
> 2. Food, water, air, light, minerals, or other nutritional or physiological requirements;
>
> 3. Cover or shelter;
>
> 4. Sites for breeding, reproduction, rearing of offspring, germination, or seed dispersal; and
>
> 5. Habitats that are protected from disturbance or are representative of the historic geographical and ecological distributions of a species.

*Id.* The BiOp explained that, in designating critical habitat for the Delta smelt, FWS identified the following primary constituent elements "essential to the conservation of the species":

> Physical habitat, water, river flow, and salinity concentrations required to maintain delta smelt habitat for spawning, larval and juvenile transport, rearing, and adult migration.
>
> ***
>
> Specific areas that have been identified as important delta smelt spawning habitat include Barker, Lindsey, Cache, Prospect, Georgiana, Beaver, Hog, and Sycamore sloughs and the Sacramento River in the Delta, and





> tributaries of northern Suisun Bay.
>
> Larval and juvenile transport. Adequate river flow is necessary to allow larvae from upstream spawning areas to move to rearing habitat in Suisun Bay and to ensure that rearing habitat is maintained in Suisun Bay. To ensure this, X2 must be located westward of the confluence of the Sacramento-San Joaquin Rivers, located near Collinsville (Confluence), during the period when larvae or juveniles are being transported, according to historical salinity conditions. X2 is important because the "entrapment zone" or zone where particles, nutrients, and plankton are "trapped," leading to an area of high productivity, is associated with its location. Habitat conditions suitable for transport of larvae and juveniles may be needed by the species as early as February 1 and as late as August 31, because the spawning season varies from year to year and may start as early as December and extend until July.
>
> Rearing habitat. An area extending eastward from Carquinez Strait, including Suisun, Grizzly, and Honker bays, Montezuma Slough and its tributary sloughs, up the Sacramento River to its confluence with Three Mile Slough, and south along the San Joaquin River including Big Break, defines the specific geographic area critical to the maintenance of suitable rearing habitat. Three Mile Slough represents the approximate location of the most upstream extent of historical tidal incursion. Rearing habitat is vulnerable to impacts of export pumping and salinity intrusion from the beginning of February to the end of August.
>
> Adult migration. Adequate flow and suitable water quality is needed to attract migrating adults in the Sacramento and San Joaquin river channels and their associated tributaries, including Cache and Montezuma sloughs and their tributaries. These areas are vulnerable to physical disturbance and flow disruption during migratory periods.

(AR 368-69.)

The BiOp acknowledges that this Delta smelt critical habitat has been adversely affected by numerous activities, but indicates that the 1994 and 1995 OCAP BiOps "provide a substantial part of the necessary riverine flows and estuarine outflows that allow smelt larvae to move downstream to suitable rearing habitat...outside the influence of marinas, agricultural

diversions, and Federal and State pumping plant." (AR 371.) The BiOp also explains that increasing demands for surface water "would likely result in lower delta outflows and increased entrainment," but that the impacts of these demands "have not altered critical habitat's conservation function for the delta smelt, and the smelt's primary constituent elements essential to the conservation of the species still function." (*Id.*) Finally, the BiOp concludes:

> In evaluating the Status of the Species for critical habitat and the Environmental Baseline, while there are current actions that result in adverse effects to delta smelt critical habitat, the primary constituent elements continue to remain functional for the smelt. In the effects section, the Service determined that the primary constituent elements of delta smelt critical habitat would not be affected by the proposed project since there will not be a loss of physical habitat in the delta, river flows will continue to provide habitat, salinity will not be affected by the proposed project, and no breeding habitat will be affected and the sustainability of the food base will not be affected. In the cumulative effects section, we determined that the cumulative effects of the proposed action are not expected to alter the magnitude of future actions' effects on critical habitat's conservation function for the smelt. Based on the analysis in these four areas, it is our conclusion that Critical habitat is not likely to be adversely modified or destroyed as a result of implementing the proposed project.

(AR 469 (emphasis added).)

These conclusions are not supported by most recent smelt data to corroborate that the primary constituent elements of Delta smelt habitat will still function in a manner consistent with conservation (i.e. recovery). The functions and their locations are identified, but impacts upon breeding habitat are not analyzed. Second, although "there will still be water in the Delta....whether the water will be of adequate quality and





quantity to allow the delta smelt to recover is an entirely different question." (Doc. 306 at 25.) The BiOp does not analyze the water supply, temperature, and quality under variable conditions with results that demonstrate the impact on smelt, nor is such an analysis found elsewhere in the administrative record.[35]

The analysis of the predicted movement of X2 is more specific. When X2 is located upstream of Chipps Island, smelt are vulnerable to entrainment and are located in an area that is not ideal for feeding or protection. (*See* AR 424.) FWS opines that smelt reproduce better when X2 remains in a specific area, west of the confluence of the Sacramento and San Joaquin Rivers. That smelt reproduction is increased and the fish may be located where there are better sources of food does not assure that the smelt are on a path to recovery. The DSRAM is to provide the means by which FWS will maintain X2 in the most beneficial location. As the DSRAM is uncertain, speculative, and lacking enforceable action measures, there is no reasonable assurance that X2 will be maintained in the necessary protective location.

DSRAM utilizes other trigger criteria, arguably aimed at the recovery of the smelt. (Doc. 241 at 13-14.) One criteria is the "recovery index trigger," derived from the September and October FMWT sampling. (AR 347; Sommer Decl. at ¶9a.) The number used

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[35] There is also merit to Plaintiffs' argument that "[g]iven that the very same sorts of impacts to critical habitat have contributed to the species decline, one might expect FWS to examine carefully how the continuance and magnification of these kinds of impacts could allow for the survival of the species, much less its recovery." (Doc. 306 at 5.)

to trigger the DSWG is 74, the median value of the recovery index for the 1980-2002 period. Whenever the recovery index falls below this median, the DSWG convenes to decide whether to recommend actions. (AR 346-47.) Use of the term "recovery" in the title of the trigger index, suggests that this index will serve to monitor the potential for the smelt population to recover. This title is inaccurate. All that this trigger criteria monitors is whether the abundance of smelt drops below the 1980-2002 median abundance. As smelt have been in decline throughout the period to February 2005, the opinion that maintaining abundance slightly above this median leads to recovery of the smelt is unjustified.

The temperature trigger criterion of 12 - 18°C, the range within which the most smelt spawning occurs, is more arguably focused on recovery. (AR 347.) If the number of days falling within the temperature range is 39 days or less by April 15, or 50 days or less by May 1, DSWG is triggered. This trigger is arguably related to the recovery of smelt, because it focuses on spawning. However, no action except a group meeting is required in response to the trigger. Moreover, maximizing the potential for smelt to spawn is only one aspect of recovery. If Project operations and/or other impacts kill more smelt than are produced during spawning, recovery does not occur. The existence of this trigger, alone, does not establish that recovery of smelt was adequately considered or addressed.[36]

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[36] The San Luis Parties correctly note that the CALSIM II models indicate that increased pumping capacity and operational flexibility may actually increase the smelt's prospects vis-a-vis





**2. The Biop Does Not Adequately Assess Impacts to All Areas of Critical Habitat.**

Plaintiffs also allege that the BiOp arbitrarily ignores impacts to certain areas of critical habitat because it focuses on X2 as a proxy for Delta smelt habitat. Plaintiffs argue that the focus on X2 ignores other areas of designated critical habitat.

The BiOp focuses on the impact project operations have had and will have on the position of X2. Defendants and Defendant-Intervenors argue that critical habitat will be protected, because any impacts to the position of X2 will be addressed by the DSRAM. The State Water Contractors contend that protecting critical habitat outside X2 "makes no sense if they are not the areas in which the fish resides." (Doc. 241 at 17.)

Plaintiffs do not dispute the notion that X2 directly relates to where most smelt are located. Rather, Plaintiffs maintain that critical habitat is not coextensive with X2. The BiOp identifies numerous areas in which smelt occur (AR 362) and acknowledges that X2 "does not necessarily regulate smelt distribution in all years." (*Id.*) Delta smelt critical habitat is defined by physical boundaries:

> California--Areas of all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Montezuma Slough; and the existing contiguous waters contained within the Delta, as defined by section 12220, of the State of California's Water Code of 1969 (a complex of bays, dead-end sloughs, channels

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the regulatory baseline. However, that the species will fare better than in the past does not assure that the totality of OCAP operations are consistent with the smelt's recovery.

> typically less than 4 meters deep, marshlands, etc.) as follows:
>
> Bounded by a line beginning at the Carquinez Bridge which crosses the Carquinez Strait; thence, northeasterly along the western and northern shoreline of Suisun Bay, including Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma Sloughs; thence, upstream to the intersection of Montezuma Slough with the western boundary of the Delta as delineated in section 12220 of the State of California's Water Code of 1969; thence, following the boundary and including all contiguous water bodies contained within the statutory definition of the Delta, to its intersection with the San Joaquin River at its confluence with Suisun Bay; thence, westerly along the south shore of Suisun Bay to the Carquinez Bridge.

59 Fed. Reg. 65,256, 65,277 (Dec. 19, 1994).

Federal Defendants respond that "the agencies have developed an operating and adaptive management system that adequately protects the existing critical habitat, that reasonably uses X2 as an evaluation tool, and that also ensures that 'additional measures' will be taken in accordance with the DSRAM to affirmatively and proactively manage habitat, as needed." (Doc. 242 at 26.) But, apart from the X2 analyses, Federal Defendants identify no other record evidence that reflects the agency analyzed impacts to critical habitat or that any "additional measures" will be required under DSRAM, as the DSRAM does not require any measure be implemented.

Defendant Intervenors assert that it is unnecessarily costly to accommodate impacts to all of the geographically designated critical habitats because the smelt are not located in the entirety of their critical habitat range all of the time. They argue the focus must be on protecting the habitat occupied by the smelt. Even if more sensible, the law requires that the agency analyze whether project operations will directly or indirectly





alter critical habitat in a way that "appreciably diminishes the value of critical habitat for both the survival and recovery of a listed species." 50 C.F.R. § 402.02. "Such alterations include, but are not limited to, alterations adversely modifying any of those physical or biological features that were the basis for determining the habitat to be critical." *Id.* The statute defines critical habitat to include both "the specific areas within the geographical area occupied by the species...on which are found those physical or biological features...essential to the conservation of the species" and "specific areas outside the geographical area occupied by the species...upon a determination by the Secretary that such areas are essential for the conservation of the species." 16 U.S.C. § 1532(5)(A). The definition of critical habitat is broader than the specific areas of occupation.

Here, the agency defined critical habitat to have a geographic scope. Absent any alterations to the critical habitat designation, the agency must address in the BiOp the full extent of impacts to the currently designated critical habitat,[37] which excluded "already degraded areas." Alternatively, the Delta

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[37] Plaintiffs raise an additional contention why the critical habitat analysis is insufficient; i.e., that the BiOp unlawfully "writes off" areas of critical habitat because they have already been degraded. For example, the BiOp concludes that "[a]n upstream movement of X2 of 0.5 km would not be significant when [X2] is located upstream of the [Sacramento-San Joaquin River] confluence because smelt habitat is already poor and the upstream movement does not result in any substantial additional loss of habitat or increase in adverse effects." (AR 443.) This issue need not be reached, as the critical habitat analysis is insufficient on other grounds. Federal Defendants are already revising the BiOp to reflect new information and new law.

smelt's critical habitat should be redefined to reflect the actual location of the smelt, if such redesignation would be consistent with law.

This has not been done. Plaintiffs motion for summary adjudication is **GRANTED** as to this issue.

**F. Did the BiOp Fail to Address the Impacts of the Whole Project?**

**1. Plaintiffs' Argument That the Biop Should Have Analyzed the Effects of Constructing the SDIP, Intertie, and FRWP.**

Plaintiffs complain that the BiOp's scope is unlawfully narrow because it fails to consider all planned actions. The BiOp includes within its formal consultation, "delivery of CVP water to the proposed Freeport Regional Water Project (FRWP)" as well as the "operation of the SWP-CVP intertie." The BiOp designates as an early consultation issue "operations of components of the South Delta Improvement Program (SDIP)," which include "permanent barrier operations in the South Delta." (AR 248.) The effects of constructing the FRWP, the Intertie, and the permanent barriers are to be covered in separate formal consultations. (AR 256, 339, 341, 421.)

The ESA requires FWS to address impacts associated with the entire agency action. *See Conner*, 848 F. 2d at 1453-54 (holding that agency violated ESA by choosing not to analyze the effects of all stages of oil and gas activity on federal lands). According to ESA regulations, the effects of an agency action include "direct and indirect effects of an action on the species or critical habitat, together with the effects of other





activities that are interrelated or interdependent with that action, that will be added to the environmental baseline." 50 C.F.R. § 402.02. "The meaning of 'agency action' is determined as a matter of law by the Court, not by the agency." *Greenpeace II*, 80 F. Supp. 2d at 1146 (citing *Pacific Rivers Council v. Thomas*, 30 F.3d 1050, 1054 (9th Cir. 1994).)

The BiOp explains its approach to scope as follows:

> The proposed action is to continue to operate the CVP and SWP in a coordinated manner. In addition to current day operations, several future actions are to be included in this consultation. These actions are: (1) increased flows in the Trinity River, (2) 8500 Banks, (3) permanent barriers operated in the South Delta, (4) an intertie between the California Aqueduct (CA) and the Delta-Mendota Canal (DMC), (5) a long-term EWA, (6) delivery of CVP water to the FRWP, and (7) various operational changes that are identified in this project description. Some of these items will be part of early consultation including 8500 Banks, permanent barriers and the long-term EWA. These proposed actions will come online at various times in the future. Thus, the proposed action is continued operation of the Project without these actions, and operations as they come online.
>
> The actions listed in the preceding paragraph are not being implemented at present; however, they are part of the future proposed action on which Reclamation is consulting. Only the operations associated with the proposed activities are addressed in this consultation; i.e., the activities do not include construction of any facilities <u>to implement</u> the actions. All site specific/localized activities of the actions such as construction/screening and any other site specific effects will be addressed in separate action specific section 7 consultations.

(AR at 256 (emphasis added).) In sum, only those aspects of the 2004 OCAP that will be implemented without further approval were the subject of formal consultation. However, certain other changes that will be effectuated in the future were the subject of early consultation. With respect to future operational changes, including some subject to formal consultation, full

implementation will require the construction of specified facilities. The impact of the construction activities themselves will be the subject of separate § 7 consultation.

Plaintiffs argue that the BiOp should have addressed the full impacts of construction of the Intertie, Freport diversion, and the SDIP because those projects are within the scope of the agency action as a whole and are "interrelated and interdependent" with the 2004 OCAP.[38]

In response, Federal Defendants cite the Endangered Species Consultation Handbook, which explains, in a hypothetical example, that operation of an existing dam project need not be considered an interrelated or interdependent activity, where the agency action being evaluated in a biological opinion was the addition

[38] The San Luis Parties cite *Gifford Pinchot* in support of the proposition that this is a properly "tiered" biological opinion. *In Gifford Pinchot*, the Ninth Circuit approved for the the tiering of a biological opinion for timber harvests in specified forest areas. The no jeopardy conclusion contained in that biological opinion relied on compliance with a very thorough, overarching forest management plan that was previously approved by the court. 378 F.3d at 1067-68. *Gifford Pinchot* allowed the agency to tier its BiOp of a timber harvest with a programmatic forest management plan that provided guidelines regarding the harvesting of timber. *Rodgers*, 381 F. Supp. 2d at 1228 n.27, interpreted the holding narrowly to apply tiering only to cases in which the programmatic opinion was particularly thorough. Tiering of future construction projects is not appropriate here, because the BiOp provides no programmatic guidelines regarding construction activities. However, just because the later projects cannot be "tiered" off the current BiOp does not mean they must be included in the current BiOp. The relevant inquiry is whether the construction projects are interrelated to and/or interdependent upon the BiOp and the 2004 OCAP.





of a new turbine to an existing dam.[39] (Handbook at 4-25 to 4-29.) Although not cited by the Federal Defendants for this purpose, the Handbook also describes a general approach FWS should use when determining whether certain actions are "interrelated or interdependent," so as to be considered part of the action:

> Interrelated and interdependent actions: Effects of the action under consultation are analyzed together with the effects of other activities that are interrelated to, or interdependent with, that action. An interrelated activity is an activity that is part of the proposed action and depends on the proposed action for its justification. An interdependent activity is an activity that has no independent utility apart from the action under consultation. (Note: the regulations refer to the action under consultation as the "larger action" [50 CFR § 402.02]).....
>
> As a practical matter, the analysis of whether other activities are interrelated to, or interdependent with, the proposed action under consultation should be conducted by applying a "but for" test. <u>The biologist should ask whether another activity in question would occur "but for" the proposed action under consultation</u>. If the answer is "no," that the activity in question would not occur but for the proposed action, then the activity is interrelated or interdependent and should be analyzed with the effects of the action. If the answer is "yes," that the activity in question would occur regardless of the proposed action under consultation, then the activity is not interdependent or interrelated and would not be analyzed with the effects of the action under consultation. There will be times when the answer to this question will not be apparent on its face. The biologist should ask follow-up questions to the relevant parties to determine the relationship of the activity to the proposed action under consultation. It is important to

[39] Federal Defendants correctly point out that the FWS uses as a guidance document the ESA Section 7 Consultation Handbook (March 1998), available at "http://www.fws.gov/endangered/consultations/s7hndbk/s7hndbk.htm" (last visited Apr. 27, 2006). *See e.g., Oregon Natural Res. Council v.* Allen, 476 F.3d 1031, 1039 n.7 (9th Cir. 2007); Ariz. *Cattle Growers' Ass'n v. U.S. Fish & Wildlife Serv.*, 273 F.3d 1229 (9th Cir. 2001); .

> remember that interrelated or interdependent activities are measured against the proposed action. That is, the relevant inquiry is whether the activity in question should be analyzed with the effects of the action under consultation because it is interrelated to, or interdependent with, the proposed action. Be careful not to reverse the analysis by analyzing the relationship of the proposed action against the other activity. For example, as cited below, if the proposed action is the addition of a second turbine to an existing dam, the question is whether the dam (the other activity) is interrelated to or interdependent with the proposed action (the addition of the turbine), not the reverse.

Section 7 Handbook at 4-26.

Here, applying the Handbook test, the question is whether the other activities (construction and operation of SDIP, Freeport, and the Intertie) are interrelated to or interdependent with the proposed actions subject to formal consultation? The formal consultation, as described in the BiOp, covers

> ...the proposed 2020 operations of the CVP including the Trinity River Mainstem ROD (Trinity ROD) flows on the Trinity River, the increased water demands on the American River, the <u>delivery of CVP water to the proposed Freeport Regional Water Project (FRWP)</u>, water transfers, the long term Environmental Water Account (EWA), the operation of the Tracy Fish Facility, and <u>the operation of the SWP-CVP intertie</u>. The effects of operations of the SWP are also included in this opinion and include the operations of the North Bay Aqueduct, the Suisun Marsh Salinity Control Gates, the Skinner Fish Facility and water transfers.

(AR 248 (emphasis added).) The formal consultation admittedly covers <u>delivery</u> of CVP water to the proposed FRWP and operation of the Intertie. But, the BiOp expressly excludes the impacts of construction associated with FRWP or the Intertie:

> The actions listed in the preceding paragraph [including permanent barriers in the South Delta, an intertie, and the FRWP] are not being implemented at present; however, they are part of the future proposed action on which Reclamation is consulting. <u>Only the operations associated with the proposed activities are</u>





> <u>addressed in this consultation; i.e., the activities do not include construction of any facilities to implement the actions</u>. All site specific/localized activities of the actions such as construction/screening and any other site specific effects will be addressed in separate action specific section 7 consultations.

(AR 256 (emphasis added).)

Is there a "but-for" relationship between the 2004 OCAP and the new projects? The FRWP and the Intertie are designed to more effectively distribute CVP and SWP waters. There is no evidence in the record indicating that construction of either project is tied in any way to the pre-approval of delivery of water to the projects. Flow operations could be approved <u>after</u> or simultaneously with the approval of new construction. Under the Handbook test, the construction projects are not considered interdependent and interrelated. These projects may be consulted upon separately. By approving a flow regime before the construction, the Bureau may plann for the <u>possibility</u> that the FRWP will be constructed in the future. The entire OCAP BiOp would not need to be revised should the projects be constructed. This is a reasonable approach.

With respect to the SDIP, the BiOp currently excludes <u>both</u> its operation and related construction coverage under the formal consultation. Plaintiffs allege that <u>both</u> should have been covered by the BiOp because they are interrelated with or interdependent on the agency action. Applying the Handbook analysis, the operation and construction of the SDIP (which includes increased pumping at Banks and operation of permanent barriers) will not occur "but for" the approval of the 2004 OCAP for CVP-SWP operations? Each action is independent of the 2004

OCAP. The SDIP is a separate addition that may or may not be constructed. Project operations under the 2004 OCAP in no way depend upon the SDIP. There is no prohibition to addressing the future operation, if and when the construction of the SDIP will occur, in a separate consultation.

Plaintiffs' motion for summary adjudication is **DENIED** as to the future projects issue.

**2. Plaintiffs' Argument that the BiOp Failed to Analyze the Impact of Full Contract Deliveries.**

A biological opinion must consider the effects of the entire agency action, meaning "all activities or programs of any kind authorized, funded, or carried out," including "the granting of...contracts." 50 C.F.R. § 402.02. One of the primary purposes of the 2004 OCAP is to "deliver water supplies to affected water rights holders as well as project contractors." (AR 259.) The Bureau delivers water to numerous parties pursuant to long-term contracts ("CVP Contracts"), some of which were renewed shortly after the BiOp was issued. (AR 4732, 4796, 4855.)

The CALSIM II model incorporated water deliveries into its various flow scenarios, but only performed its analysis based on the effects of delivering between 11 and 89 percent of the full CVP Contract allocations. (*See* AR 1067; see also Doc. 242 at 31 (acknowledging that the agency "did not evaluate the impacts of 100% percent delivery of all contracted waters").) This range of delivery scenarios is based on historic average water deliveries.

Plaintiffs allege that, by failing to evaluate the impact of delivering full amount (100%) of contracted water, the BiOp





violates the requirement that the it evaluate the entire agency action. Plaintiffs cite *Rodgers*, 381 F. Supp. 2d at 1237-40, which examined a biological opinion approving long term water contracts in the Friant, Buchanan, and Hidden water units of the CVP. The BiOp only examined the impacts of the amount of historical water deliveries, which amounted to less than half of the water deliveries authorized under the long term water service contracts. *Id.* at 1237-28.

> The Friant long-term contracts cumulatively authorized the Bureau to deliver more than 2.1 million acre-feet of water per year, for twenty-five years. Rather than analyzing the effects of 2.1 million acre-feet of water delivery, FWS explained that its "effects analysis is conducted under the expectation that water will be delivered to CVP service contractors in quantities that approximate historic deliveries (1988 through 1997), as given in Appendix D of the November 21, 2000 programmatic long-term CVP contracts consultation." This assumption was made, the BiOp explained, because "delivery of full contract quantities is unrealistic."

*Id.* at 1238. *Rodgers* rejected FWS's approach, reasoning that the "ESA requires that all impacts of agency action-both present and future effects-be addressed in the consultation's jeopardy analysis."

> The fact that it was thought by FWS that "delivery of full contract quantities is unrealistic" and that "deliveries continue to be impacted by existing climate, hydrology, actions and statutes, ... socio-economic factors" does not excuse consulting on the "entire agency action," which was the authorized delivery of over 2.1 million acre-feet of water, and nothing less than that.

*Id.* at 1239.

Federal defendants assert that the *Rodgers* decision was wrong, arguing that "[a]bsent alternative information that the agency failed to consider, and given the fact that the agency did

use the best available information, the *Rodgers* court should have deferred to the agency." (Doc. 242 at 32.) It is not the province of another district court to decide whether *Rodgers* is "wrong." *Rodgers* is distinguishable as it specifically addressed the government authorization of CVP water users' long-term water service contracts. Those contracts authorized 2.1 MAF of water deliveries in total. *Rodgers* found unlawful the biological opinion's limitation in its scope to approximate historic deliveries, instead of the full contract allocations. Here, however, the agency action subject to consultation is not the authorization or merits of the water service contracts, rather, it is the operation of the CVP and SWP under the OCAP and whether those projected operations will cause jeopardy to the survival and recovery of smelt or smelt habitat. The government is entitled to make reasonable assumptions about the operational volume of water flows, water levels, temperature, and quality based on the historical and projected data in the administrative record. The BiOp explains that the delivery of full water service contract entitlements is expected only when excess water conditions exist, i.e., in a wet water year when sufficient water is available to meet all beneficial needs. (AR 259.) Plaintiffs do not suggest that this assumption is factually impossible. (Nor would it be unreasonable for FWS to model a full (100%) water contract delivery scenario, even if it has not happened in the past fifteen years.) The agency model for the worst case scenario is indispensable. Analysis of a "best of the best" case in a wet water year is not indispensable, as such "wet" water year conditions do not present any reasonable likelihood of





jeopardy, absent an additional showing. However, because such a scenario could eventuate, it is not unlawful for the agency to analyze the effects on the smelt of 100% water contract deliveries. However, the 100% delivery analysis is not required. This is a matter committed to the agency's expertise and discretion.

Plaintiffs motion for summary adjudication is **DENIED** as to this issue.

## VIII. CONCLUSION

As the history of the many CVP water cases decided in this court evidences, the duty to defer to the agency's expertise is well recognized and honored, when the agency has acted reasonably and lawfully to discharge its statutory responsibilities. The disputed BiOp depends in material measure for its no jeopardy finding on the DSRAM, which is legally insufficient. The agency's recognition the Delta smelt is increasingly in jeopardy; that its operative BiOp is inadequate, as evidenced by its second initiation of reconsultation for the 2004 OCAP, now pending, and its insistence that it will nonetheless operate the Projects under the challenged BiOp is unreasonable. The agency could have, but did not, offer a viable protective alternative. Adaptive management is within the agency's discretion to choose and employ, however, the absence of any definite, certain, or enforceable criteria or standards make its use arbitrary and capricious under the totality of the circumstances.

The agency's failure to reasonably estimate the Delta smelt population and to analyze most recent smelt abundance data make

the take limits based on historical data unreliable and unreasonable. The Delta smelt is undisputedly in jeopardy as to its survival and recovery. The 2005 BiOp's no jeopardy finding is arbitrary, capricious, and contrary to law.

For all the reasons set forth above, the 2005 OCAP BiOp is unlawful and inadequate on the following grounds:

(1) The DSRAM, as currently structured, does not provide a reasonable degree of certainty that mitigation actions will take place, even if the agency retains the discretion to draw upon numerous sources of water, not just the EWA, CVPIA(b)(2), and VAMP programs, to support fish protection.

(2) The agency failed to utilize the best available scientific information by not addressing the 2004 FMWT data and the issue of climate change.

(3) The BiOp's historical approach to setting take limits fails to consider take in the context of most recent overall species abundance and jeopardy.

(4) The BiOp did not adequately consider impacts to critical habitat by (a) failing to analyze how project operations will impact the value of critical habitat for the recovery of the smelt and (b) failing to consider impacts upon the entire extent of known smelt critical habitat.

The Plaintiffs' motions for summary judgment are GRANTED IN PART AND DENIED IN PART, as delineated above.

Based on the legally flawed BiOp, an appropriate interim





remedy must be implemented. All parties agree that it is not prudent to impose a remedy without further input from the parties. A separate remedies hearing will be scheduled within thirty days at the parties' mutual convenience.[40] During oral argument, Federal Defendants and Defendant-Intervenors jointly requested a stay of any order finding the BiOp unlawful to avoid the draconian consequences of operating the CVP-SWP without a lawful take limit. Affording all parties the opportunity to participate in a remedies hearing will not jeopardize the species or the public interest during interim operation of the projects. Plaintiffs did not object to such an approach.

A Scheduling Conference is set for May 30, 2007, at 8:45 a.m. in Courtroom 3 to afford the parties time for discussions to set a remedies hearing, and to consider the entry of a stay, if necessary.

Plaintiffs shall submit a form of order on the motions for summary judgment consistent with this decision within five (5) days following service of this decision.

IT IS SO ORDERED.

**Dated: May 25, 2007**

**/s/ Oliver W. Wanger**
UNITED STATES DISTRICT JUDGE

[40] The parties stated that they may be able to reach an agreement as to interim remedies, avoiding the need for a remedies hearing.

# Attachment 9

# Delta water exports halved

## It was the first cut rising from a court ruling to protect threatened smelt.

**By Matt Weiser - mweiser@sacbee.com**
***Published 12:00 am PST Saturday, December 29, 2007***

Water exports from the Sacramento-San Joaquin Delta were slashed in half Friday to protect a threatened fish, marking the first action sparked by a federal court order earlier this month.

The Dec. 14 ruling by U.S. District Judge Oliver Wanger in Fresno requires state and federal water agencies to reduce their draw from the estuary under certain conditions to protect the Delta smelt. The agencies operate separate canal systems, which serve 25 million Californians and more than 2 million acres of farms from the Bay Area to San Diego.

But those water exports have contributed to a steep decline in the population of the smelt, a fragile fingerling protected by the Endangered Species Act. The fish are not strong enough to resist the pull of the pumps, which reverse natural water flows in the Delta.

Wanger's ruling requires pumping reductions under certain conditions that affect the smelt. One of those triggers was tripped on Christmas Day when water clarity declined at a South Delta monitoring site.

"It's a belated Christmas present to the Delta smelt from Judge Wanger," said Bill Jennings, executive director of the California Sportfishing Protection Alliance. "It is a historic occasion."

DWR and the U.S. Bureau of Reclamation had three days to respond after the trigger point was reached. They did so Friday morning by reducing combined pumping from 5,250 cubic feet per second to about 2,400, said Carl Torgersen, chief of operations and maintenance for the state Department of Water Resources.

The goal is to minimize reverse flows in the Delta to meet a threshold set by the court. The result, Torgersen said, will be about 5,600 acre-feet of water per day not delivered to users. That's enough water for about 10,000 average households for a year.

The cutback probably won't have an immediate effect. Torgersen said it will hinder the ability to refill San Luis Reservoir near Los Banos, a storage point for the southbound water.

But there could be long-term shortages, particularly if 2008 ends up being a drought year.

The pumping reductions must continue for 10 days unless rainfall substantially boosts natural runoff through the Delta.

"But we don't see that in the forecast," Torgersen said. "The effects of the Wanger decision can vary greatly and I wouldn't be able to say right now that it's actually putting us in a drought or not. That's a tough one."

The Zone 7 Water Agency, which serves about 200,000 customers around Livermore and Pleasanton, draws from the state's Delta canal before water reaches San Luis Reservoir. As a result, it could be among the first to suffer from pumping reductions.

"While this one cutback won't impact our customers' taps, it is going to reduce our supply of water for the year," said spokeswoman Boni Brewer. "Obviously the Delta habitat is in trouble and we're hoping there's some solution that can protect that habitat and long-term water supplies."

Zone 7 has already increased residential water rates by about $2.25 per month to pay for conservation measures and emergency supplies. Officials have also urged customers to reduce consumption by 10 percent.

The smelt's plight is viewed by many biologists as a warning of larger ecosystem troubles in the Delta. The smelt's decline is blamed on pumping effects as well as poor water quality, competition from invasive species, and loss of habitat and food.

Wildlife officials are preparing a new court-ordered management plan for the smelt, which may include water delivery rules that could make Friday's pumping reductions commonplace.

State officials are also studying long-term solutions, including major habitat restoration projects and new ways to move farm and domestic water around the Delta, such as a canal.

Go to: Sacbee / Back to story

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# Attachment 10

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Attorneys for Defendant-Intervenor

IN THE UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF CALIFORNIA

| | |
|---|---|
| **NATURAL RESOURCES DEFENSE COUNCIL, et al.,**<br>Plaintiffs,<br>v.<br>**DIRK KEMPTHORNE, in his official capacity as Secretary of the Interior, et al.,**<br>Defendants,<br>**SAN LUIS & DELTA-MENDOTA WATER AUTHORITY and WESTLANDS WATER DISTRICT; CALIFORNIA FARM BUREAU FEDERATION; GLENN-COLUSA IRRIGATION DISTRICT, et al.; CALIFORNIA DEPARTMENT OF WATER RESOURCES, and STATE WATER CONTRACTORS,**<br>Defendant-Intervenors. | 05 CV 01207 OWW (LJO)<br>**DECLARATION OF JOHN LEAHIGH IN SUPPORT OF THE CALIFORNIA DEPARTMENT OF WATER RESOURCES' PROPOSED INTERIM REMEDY**<br>Hearing: August 21, 2007<br>Time: 9:00 a.m.<br>Courtroom: 3<br>Judge: Hon. Oliver W. Wanger |

I, John Leahigh, declare as follows:

1. I am employed by the Department of Water Resources (DWR) as Chief of the Project Operations Planning Branch (POPB) within the Division of Operations and Maintenance. I have been in my current position since March 2005.

2. I am responsible for short-term planning of water operations for the State Water Project (SWP). These planning responsibilities include the estimation of delivery capabilities of the SWP and forecasted water export operations from the Sacramento/San Joaquin Delta (Delta) through the Harvey O. Banks Delta Pumping Plant (Banks), Skinner Fish Protection Facility (Skinner), and Clifton Court Forebay (CCF).

3. Prior to taking the position of Chief of the POPB, I worked within the branch in various engineering classifications from November 1996 through February 2005. I have worked for DWR since May 1992. I received a Bachelor's degree in Civil Engineering from the University of New Mexico in 1989 and a Master's degree in Civil Engineering with emphasis on Water Resources Engineering from California State University at Sacramento in 1999. I am a registered Civil Engineer in the State of California.

4. One of my responsibilities as Chief of the POPB is to supervise the work of engineering staff that develop and monitor studies, projections and delivery capabilities of the SWP. I coordinate with a team of engineers to plan and schedule water export operations based on water availability, water permit/quality restrictions, environmental needs, and projected hydrology.

5. I have personal knowledge of the facts stated herein, and, if called to do so, could and would testify competently thereto.

6. I am familiar with and contributed to the development of the proposed remedy actions, set forth in the Delta Smelt Action Matrix for Water Year 2008 (Action Matrix)[1], proposed by the United States Fish and Wildlife Service (USFWS), as supported by DWR. The Action Matrix has been developed to minimize and prevent adverse impacts to delta smelt and its habitat from SWP and CVP operations during the interim period pending completion of the consultation on the delta smelt with USFWS. I am informed and believe that the USFWS will complete the consultation and issue its biological opinion before August 2008.

///

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1. A copy of the Action Matrix is attached as Exhibit A to the Declaration of Jerry Johns in Support of the California Department of Water Resources' Proposed Interim Remedy, filed concurrently herewith.

7. I have worked with POPB staff to develop an estimate of the water costs associated with implementation of the Action Matrix through July 2008.

8. For the purposes of the following analysis, "water costs" are defined as the estimated export reductions and the estimated reductions in deliveries of water to CVP/SWP contractors for 2008 as a result of implementing the actions described in the Action Matrix.

9. The term baseline" is defined as the expected delivery of water without implementing the Actions proposed in the USFWS remedy matrix. Baseline water deliveries often vary depending on hydrology and the costs estimates are based on two different hydrology assumptions, as described in detail below.

10. Water supply forecasting requires a projection of initial reservoir storages and forecasted runoff as a foundation to delivery estimates. Reliable projections are available for the initial reservoir storages going into 2008, but the forecasted runoff is largely dependent on the amount of precipitation that will be experienced next year, which is unknown and could vary greatly. Water supply costs were analyzed for 2008 with two different assumptions on the amount of precipitation that may be experienced in 2008: dry and average.

11. A year with low precipitation or a "dry year" for the purposes of my analysis assumes the amount of precipitation in 2008 will be equal to the amount of precipitation that was exceeded 90% of the time over the past 85 years.

12. A year with average precipitation or an "average year" for the purposes of my analysis assumes the amount of precipitation in 2008 will be equal to the amount of precipitation that was exceeded 50% of the time over the past 85 years.

13. Although many different assumptions could be made for the amount of precipitation that could occur in any year, assumptions of precipitation at a 90% and 50% chance of exceedence are the most widely used water supply forecasting assumptions. These two hydrologic assumptions generally give a good analytical range for project operations.

## EXISTING RESTRICTIONS ON WATER DELIVERIES

14. DWR provides water to twenty-nine (29) contractors throughout California under water right permits issued by the State Water Resources Control Board (SWRCB). These permits

include restrictions on water exports. The DWR permit most recently issued by the SWRCB resulted in a SWRCB decision, known as Water Rights Decision 1641 (D-1641). Details of the decision can be found at 14. DWR provides water to twenty-nine (29) contractors throughout California under water right permits issued by the State Water Resources Control Board (SWRCB). These permits include restrictions on water exports. The DWR permit most recently issued by the SWRCB resulted in a SWRCB decision, known as Water Rights Decision 1641 (D-1641). Details of the decision can be found at http://www.waterrights.ca.gov/baydelta/d1641.htm.

15. The water costs associated with the Action Matrix are measured against allowable deliveries under baseline operations, considering all flow and water quality objectives required by D-1641. Through D-1641, the SWRCB assigns responsibility for meeting water quality objectives adopted in the Water Quality Control Plan ("WQCP") for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. These WQCP objectives protect fish and wildlife, and the agricultural, municipal and industrial uses of water.

16. The WQCP was updated in 2006. The new plan did not result in any changes in the requirements of D-1641. The new WQCP can be found at http://www.waterrights.ca.gov/baydelta/docs/rev2006wqcp.pdf.

17. A team of engineers and I took into account the restrictions imposed by meeting the objectives of the WQCP when developing the estimates for water costs associated with the implementation of the Action Matrix.

**ASSUMPTIONS FOR THE IMPLEMENTATION OF ACTIONS**

18. I assumed in the analysis that Action 1 would be triggered and implemented as of December 25, 2007 and continue through January 3, 2008. December 25 is described as the first possible day to trigger this 10-day Action in the Action Matrix.

19. I assumed in the analysis that delta smelt spawning will occur on February 20, 2008. February 20 is the date on which DWR biologists have estimated that spawning has begun historically. This assumption establishes the durations of Actions 2 and 3, which could vary significantly. The end of Action 2 and the trigger for the start of Action 3 is the onset spawning

as described in the Action Matrix.

20. In the Action Matrix, Actions 3 and 4 assume a range of flow objectives. A range of Old and Middle River upstream flows between 0 and 4000 cubic feet per second (cfs) is explicitly described and assumed for analyzing Action 3.

21. Action 4 does not have targeted flow but allows a range similar to Action 3 (from zero to approximately 4000 cfs).

22. Because the Action Matrix describes Actions 3 and 4 flow objectives as a range I assumed a range for water costs as well. The high end of this range assumes that the Old and Middle River objective is 0 cfs for both Actions 3 and 4. For determining the lower costs in the range I assumed that Action 3 is implemented at the 4000 cfs flow objective and Action 4 is not triggered, resulting is no water costs.

23. This range of cost was necessary as part of the analysis because of the uncertainty related to the real-time distribution of delta smelt and the susceptibility of this distribution to the exports as noted in footnotes of the Action Matrix.

## ESTIMATED EXPORT REDUCTIONS ASSOCIATED WITH THE USFWS'S REMEDY PROPOSAL

24. Implementation of flow objectives in the Action Matrix will require reductions in export operations by the SWP and CVP. My team of engineers and I estimated ranges of export reductions associated with each Action in the Action Matrix. The ranges are based on 2008 being dry or having average precipitation as defined earlier. In addition, Actions 3 and 4 have sub-ranges due to their adaptive nature.

25. Action 1 - Winter Pulse Flow to Benefit Adult Spawning: CVP and SWP target upstream Old and Middle River flow not to exceed 2,000 cfs for a 10-day period during late December or early January. This action is estimated to reduce combined project exports by 100 thousand acre-feet (taf) in a dry year and 160 taf in an average year.

26. Action 2 - Adult Salvage Minimized: CVP and SWP target upstream Old and Middle River flow not to exceed 4,500 cfs from early January to late February. This action is estimated to reduce combined project exports by 150 taf in a dry year and 500 taf in an average year.

27. Action 3 – Larval and Juvenile Protection: CVP and SWP target upstream Old and Middle River flow between 4,000 cfs to 0 cfs from late February through the end of May. This action is estimated to reduce combined project exports by 60 taf to 500 taf in a dry year and 640 taf to 1.3 million-acre feet (maf) in an average year.

28. Action 4 – Juvenile Protection: If triggered, the CVP and SWP may target upstream Old and Middle River flow of up to 0 cfs in June. This action is estimated to reduce combined project exports up to 130 taf in a dry year and up to 350 taf in an average year.

29. Action 5 - Barrier Operations: There were no additional export reductions associated with this action.

**COMBINED SWP/CVP ESTIMATED DELIVERY REDUCTIONS**

30. I assumed in my analysis that both the SWP and CVP are equally responsible for meeting the objectives in the Action Matrix. The estimated delivery reductions provided below represent combined CVP/SWP delivery reductions.

31. Export reductions do not result in a one-for-one impact on deliveries because of a multitude of complicating factors including system constraints, runoff patterns, annual delivery patterns, and operational flexibility.

32. The export reductions for each action were entered into an operational spreadsheet model developed by DWR staff that estimates the delivery capabilities of the SWP and CVP. We modeled the remedy period with the implementation of the Action Matrix and without implementation of the Action Matrix. A comparison of model output indicates what annual delivery reduction could occur in 2008 if all proposed actions are implemented.

33. The resulting delivery reductions are expressed as a range for each hydrologic assumption for the same reason that the export reductions were expressed as a range. Actions 3 and 4 of the Action Matrix have an adaptive management process that will vary the flow objective.

34. The conclusion of the analysis is that the sum of all these export reductions in a dry year is expected to decrease combined 2008 deliveries of the SWP and CVP by 6% (183 taf) to 25% (814 taf) from a baseline delivery of 3.2 maf.

35. In an average year, the delivery reductions are expected to be between 14% (820 taf) to 37% (2.17 maf) from a baseline delivery of 5.9 maf.

**SWP SHARE OF ESTIMATED DELIVERY REDUCTIONS**

36. The analysis showed that the SWP 2008 annual deliveries would be reduced 8% (91 taf) to 27% (305 taf) from a baseline delivery of 1.15 maf in a dry year.

37. In an average year, SWP 2008 annual deliveries would be reduced 8% (252 taf) to 31% (940 taf) from a baseline delivery of 3 maf.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Executed this 9th day of July, 2007 at Sacramento, California

JOHN LEAHIGH, Declarant.

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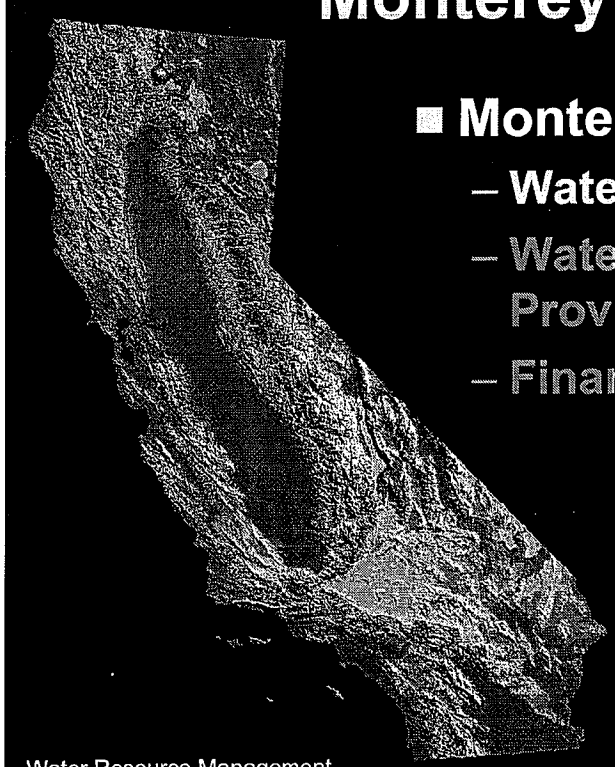
# Attachment 11

# Update on Monterey Amendment

Water Planning and Stewardship Committee
6e
January 8, 2008

1

# Monterey Analysis



- Monterey Considerations:
  - Water Allocation Provisions
  - Water Management Provisions
  - Financial Provisions

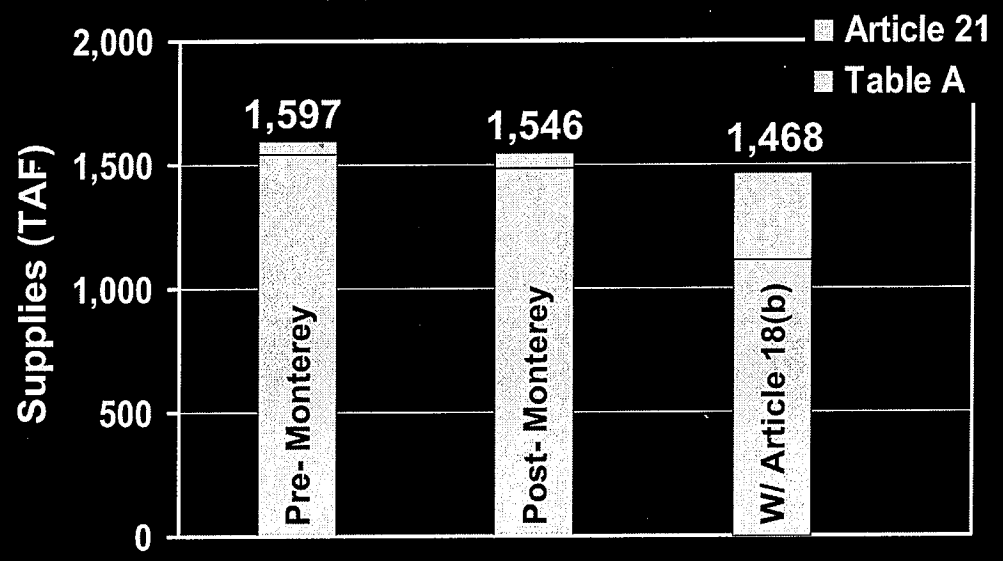
# Water Allocation Provisions

- Initial Negotiation Issues
  - Initial Ag deficiency (Art. 18(a))
  - Permanent yield reduction (Art. 18(b))
- Additional Provisions
  - Access to surplus
  - Retired Table A amount
  - Table A transfers



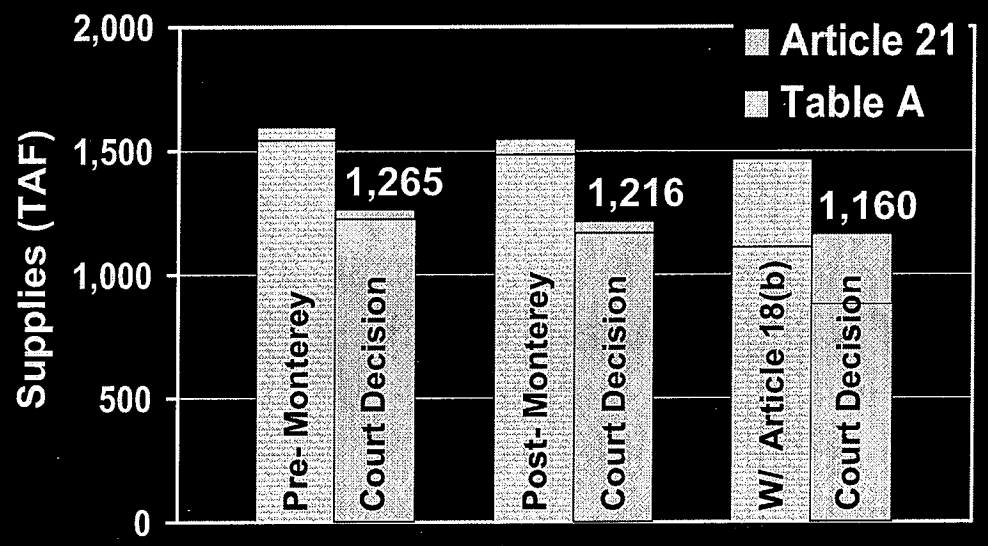
# Water Allocation Provisions

- Monterey provisions reduce risk due to Article 18(b) implementation



# Water Allocation Provisions

- Post Federal Court Decision




5

# Monterey Analysis

- Monterey Considerations:
  - Water Allocation Provisions
  - Water Management Provisions
  - Financial Provisions

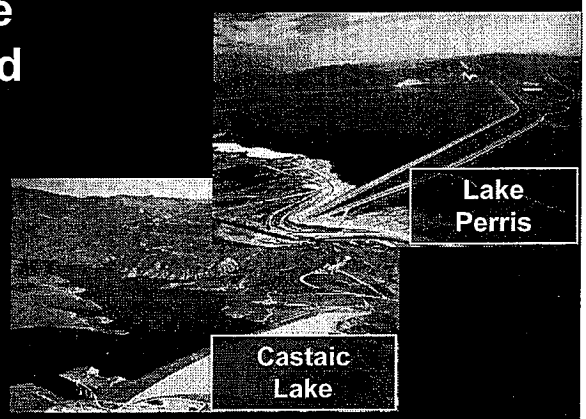


6

# Water Management Provisions

## Carryover and Flexible Storage

- 1,000,000 acre-ft (Art. 56 carryover) delivered to date
- 324,000 acre-ft flexible storage withdrawn and repaid to date

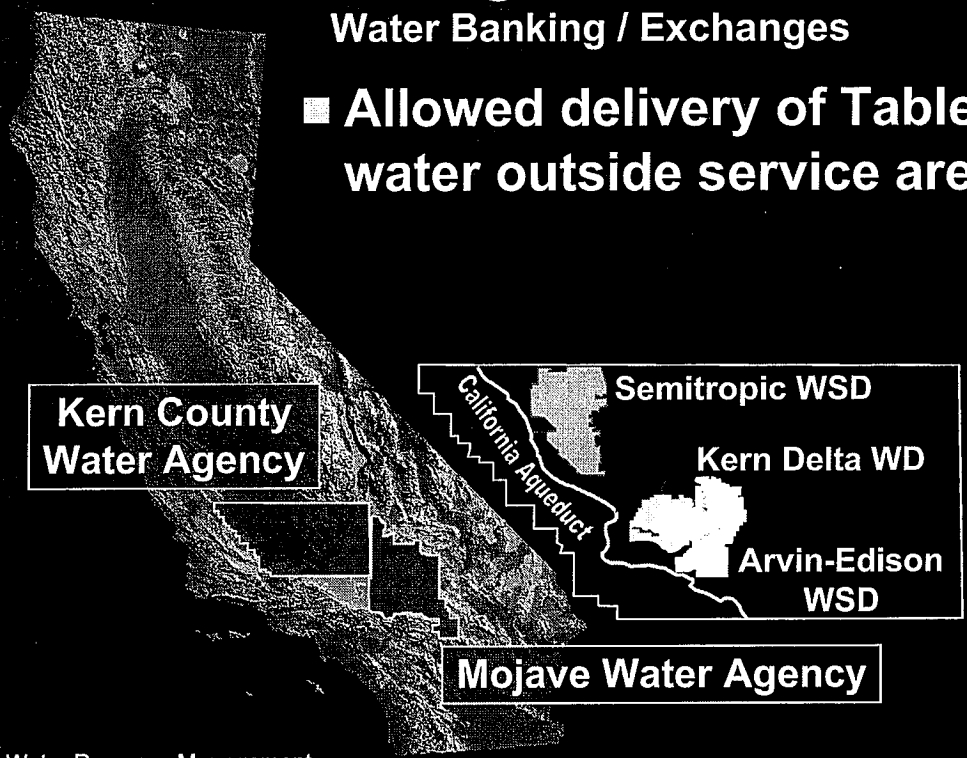





# Water Management Provisions

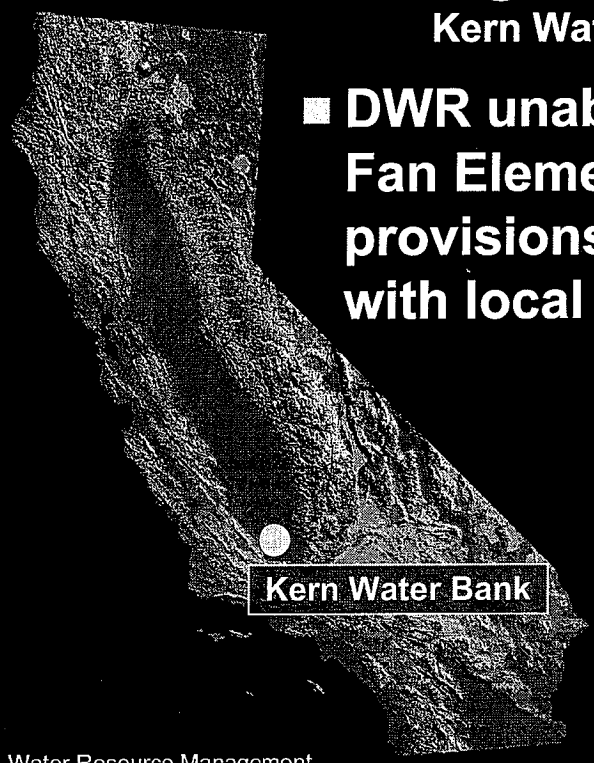
## Water Banking / Exchanges

- Allowed delivery of Table A water outside service area



# Water Management Provisions

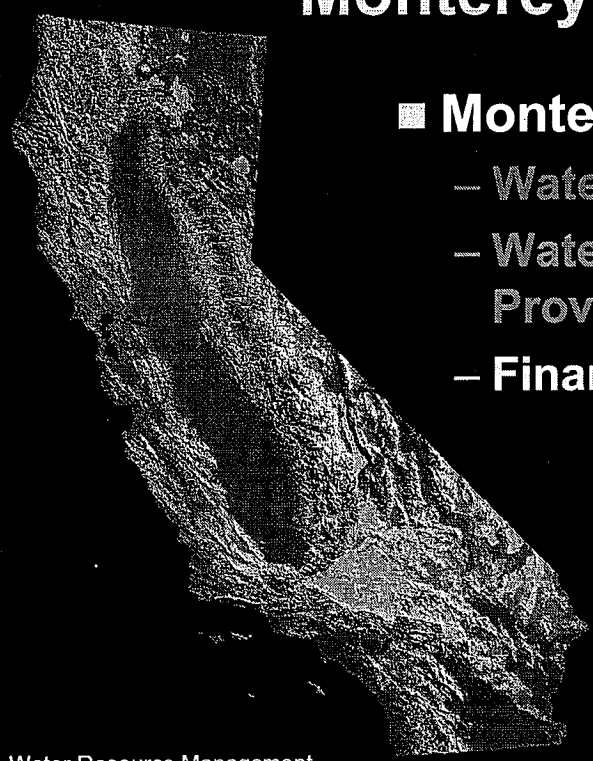
## Kern Water Bank




- DWR unable to develop Kern Fan Element due to Water Code provisions requiring agreement with local agencies



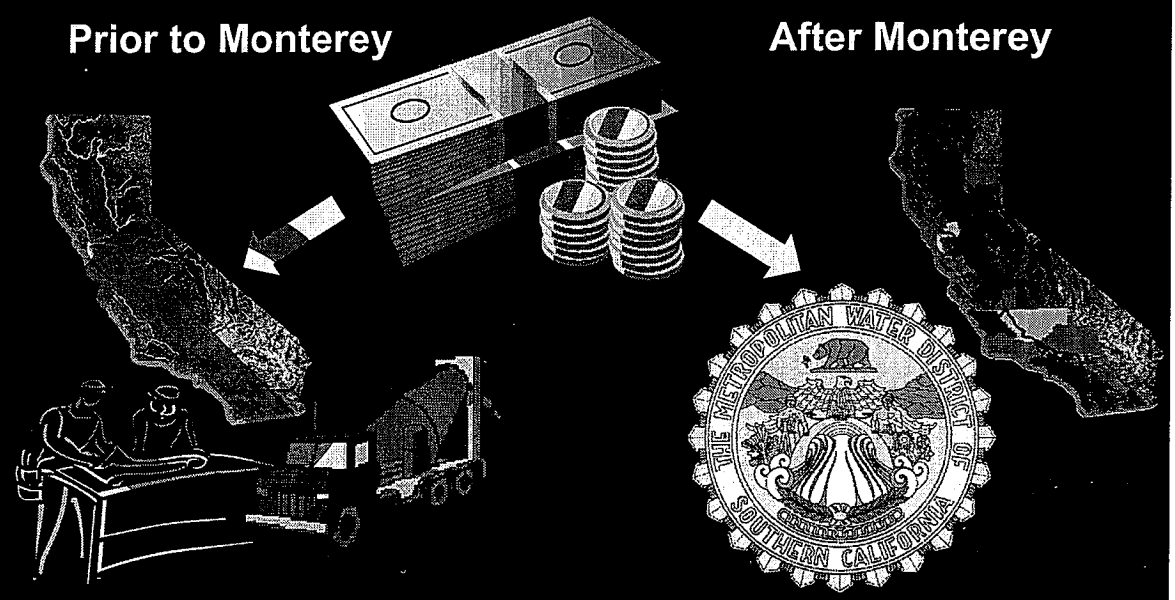
# Monterey Analysis



- Monterey Considerations:
  - Water Allocation Provisions
  - Water Management Provisions
  - Financial Provisions

# Financial Provisions

## Rate Management Credits

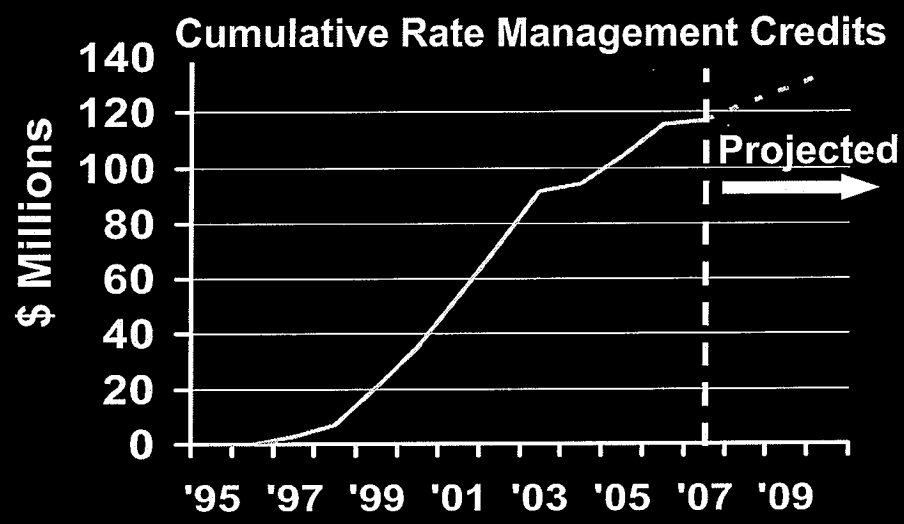





# Financial Provisions

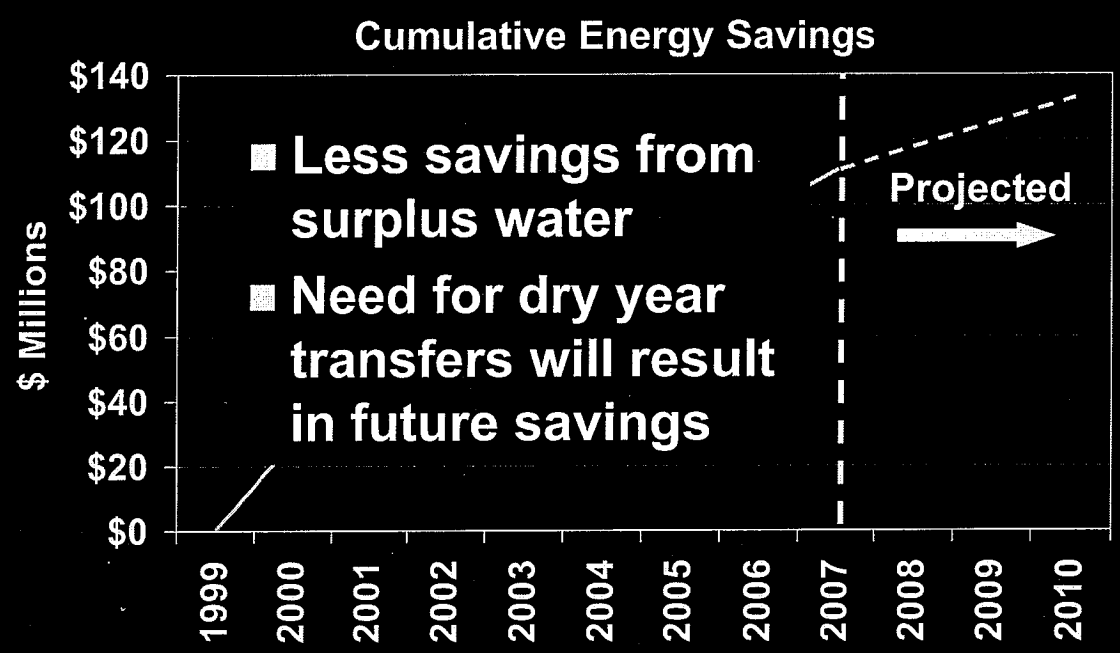
## Rate Management Credits

- **Approx. $117M total savings to date**
  - Not impacted by fishery actions



# Financial Provisions

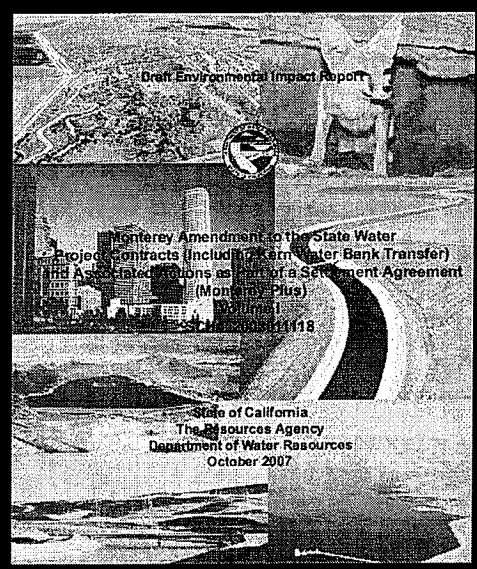
## Surplus and Transfers at Melded Energy Rate






# Monterey Plus Draft EIR

- Scope
- Alternatives
- Significant Unavoidable Impacts
- Comments due 1/14



# Summary of Monterey Amendment Provisions

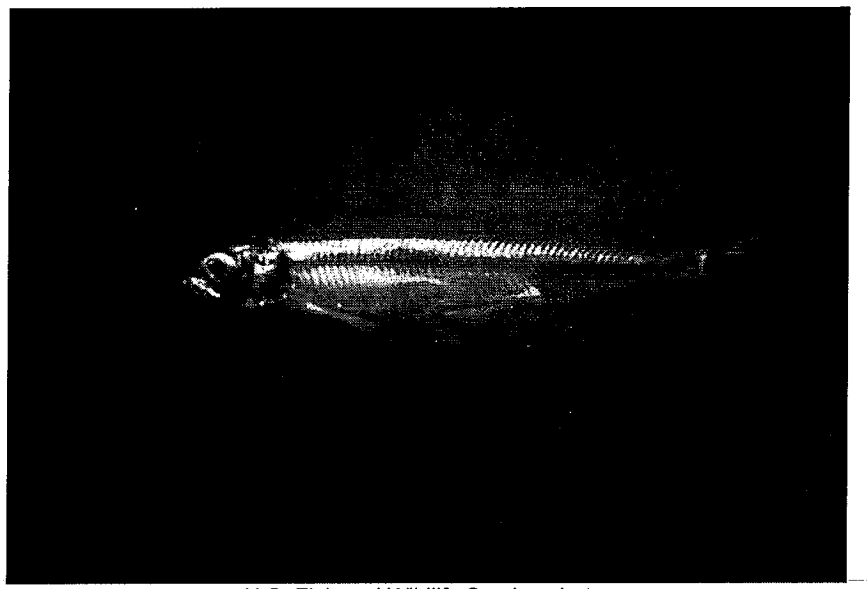
- **Water Allocation Provisions**
  - 4% reduction in Table A on average
  - Eliminate 18b and Ag preference to surplus
- **Water Management Provisions**
  - Programs incorporated into IRP
  - Surface storage at no incremental cost beneficial for managing variable deliveries
  - Existing groundwater storage will help in interim
- **Financial Provisions**
  - Rate management credits
  - Large energy cost savings on surplus and transfers

# Attachment 12

# PETITION TO THE STATE OF CALIFORNIA FISH AND GAME COMMISSION AND SUPPORTING INFORMATION FOR LISTING THE

# DELTA SMELT (*Hypomesus transpacificus*)

# AS AN ENDANGERED SPECIES UNDER THE CALIFORNIA ENDANGERED SPECIES ACT



U.S. Fish and Wildlife Service photo

**Submitted To:** California Fish and Game Commission
1416 Ninth Street
Sacramento, CA 95814

**Submitted By:** The Bay Institute
Center for Biological Diversity
Natural Resources Defense Council

**Date:** February 7, 2007

## EXECUTIVE SUMMARY

The Bay Institute, Center for Biological Diversity, and the Natural Resources Defense Council formally request that the California Fish and Game Commission change the state listing of the delta smelt (*Hypomesus transpacificus*) from threatened to endangered under the California Endangered Species Act, on an emergency basis. In the past few years, the delta smelt population has plummeted to the lowest levels ever recorded and, based on population viability analysis, the species is in imminent danger of extinction, the criterion for endangered status. Recent surveys indicate that environmental conditions in the delta smelt's critical habitat, the upper San Francisco Bay/Sacramento-San Joaquin Delta Estuary, have also declined, rendering large areas of the delta smelt spawning and rearing habitat lethal to the fish and threatening the planktonic food web upon which the species depends. The magnitude and frequency of occurrence of multiple known threats to the species are also increasing. The petitioners are conservation organizations with an interest in protecting the delta smelt and its estuarine habitat.

Delta smelt are endemic to the upper reaches of the San Francisco Bay Bay-Delta Estuary. The species requires specific environmental conditions (freshwater flow, water temperature, salinity) and habitat types (shallow open waters) within the estuary for migration, spawning, egg incubation, rearing, and larval and juvenile transport from spawning to rearing habitats. Delta smelt feed exclusively on plankton and most individual fish live only one year. Although they are restricted to a relatively small geographic range, delta smelt use different parts of the estuary at different life history stages. Throughout most of their life span, delta smelt inhabit low salinity habitat, at the interface of inflowing fresh water from the Sacramento and San Joaquin Rivers and salt water from the Pacific Ocean. Spawning adults, larvae, and young juveniles are found further upstream in the Delta, where they are vulnerable to lethal entrainment into federal, state, industrial, and local agricultural water diversion and export facilities.

As recently as thirty years ago, the delta smelt was one of the most common and abundant of the pelagic fishes in the estuary. In the early 1980s, its population declined by more than 80%, leading to threatened listings under both the federal and state Endangered Species Acts in 1993. During the 1990s, delta smelt abundance fluctuated and then increased in response to improved habitat conditions following the 1987-1992 drought. In 2002, the species' abundance again declined drastically, dropping more than 80% in just three years. For the past three consecutive years, delta smelt population abundance levels have been the lowest on record: in 2005 delta smelt abundance was the lowest ever measured, just 2.4% of the abundance measured when the species was state and federally listed in 1993, and the 2006 and 2004 abundance levels were the second and third lowest, respectively.

Population viability and extinction risk analyses indicate that delta smelt has fallen below its estimated "effective population size", with its present low abundance rendering the species vulnerable to inbreeding and genetic drift. The analyses, completed three years ago, predicted a 50% chance that the population would fall below its effective population size within two years, a prediction fulfilled by recent measurements of the species' record

low abundance in 2004, 2005 and 2006. Other analyses using the most conservative extinction criterion predicted a 26-30% probability that the delta smelt population would fall to just 800 fish (compared to the present record low population of an estimated 35,000 fish) in the next 20 years. These high probabilities of extinction for delta smelt exceed criteria established by the International Union for Conservation of Nature and Natural Resources for an "endangered" species.

There are multiple environmental and anthropogenic threats to the species, including: reductions in freshwater inflow to the estuary; loss of larval, juvenile and adult fish at the massive state and federal water export facilities and urban, agricultural and industrial water diversions; direct and indirect impacts of non-native species on the delta smelt's planktonic food supply and habitat; lethal and sub-lethal effects of toxic chemicals; and, as a result of their present low population size, potential loss of the species' genetic integrity.

The recent decline of the species coincides with significant increases in Delta water exports by the state and federal water projects (seasonal water exports in the 2000s are as much as 49% higher than in the early 1990s), higher incidental take of delta smelt by the pumps, and concomitant increased alterations in internal Delta flow patterns. New analyses have demonstrated statistically significant relationships between delta smelt population abundance and both Delta freshwater outflow and export rates: low freshwater outflows and/or high levels of water exports consistently correspond to low delta smelt population abundance. Hydrodynamic analyses of Delta flows and exports indicate that all larval and juvenile delta smelt present in the southern regions of the Delta, that part of the species' critical habitat closest to the pumps, are likely to be entrained and lost. Based on these analyses, current water management operations in the Delta are contributing to the current critically low numbers of delta smelt and are incompatible with recovery of the species.

Ecological conditions in delta smelt habitat have also deteriorated. Reduced freshwater outflows have shifted the location and degraded the low salinity habitat seasonally used by the fish. The invasive clam *Corbula amurensis* (formerly *Potamocorbula amurensis)* has reduced the abundance of the delta smelt's zooplankton food supply. All life history stages of the species are at least periodically exposed to lethal or sub-lethal concentrations of herbicides and pesticides discharged and transported from upstream into their habitat.

Current state and federal management and protective regulations have proved inadequate to protect delta smelt and their estuarine ecosystem. The current export criteria in the water rights permits issued by the State Water Resources Control Board regulations allow export operations at levels that exceed those necessary to maintain healthy delta smelt populations. Dedications of water for the environment and of money for supplemental acquisitions of environmental water mandated in the 1992 Central Valley Project Improvement Act intended to reduce the negative impacts of the federal water project on fish and wildlife have not been fully or aggressively implemented. The CALFED Bay-Delta Program has been largely ineffective in addressing environmental problems in the

Delta, and its future status is highly uncertain. The most recent Biological Opinion by the U.S. Fish and Wildlife Service (USFWS) for protection of the species relies nearly exclusively on the CALFED Environmental Water Account, an experimental fish protection tool that, after six years of implementation, has failed to provide detectable benefits for delta smelt or any other fish species. Despite precipitously declining populations of delta smelt (and other Delta fish species), the agencies charged with protecting the species under the state and federal Endangered Species Acts are in the process of approving the South Delta Improvements Program, which would increase Delta water exports and install permanent tidal barriers that further modify Delta flow patterns and habitat.

Less than three years ago, the USFWS completed a 5-year status review for delta smelt. Based on that review, the USFWS rejected a proposal to de-list the species, reaffirmed the threatened status of the species, and reported that the threats to the species had been neither eliminated nor mitigated. Since then, the condition of the species has worsened dramatically and threats to its continued existence have multiplied and escalated. The survival of delta smelt is threatened by the present and threatened modification of its habitat; human-related activities such as water diversions, entrainment and toxic chemicals; and predation, competition and other direct and indirect impacts of non-native species. The delta smelt, a potent indicator of the ecological health of the west coast's largest estuary, is at imminent risk of extinction and merits immediate listing under the California Endangered Species Act as an endangered species.

**NOTICE OF PETITION**

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Petitioners the Bay Institute, Center for Biological Diversity, and Natural Resources Defense Council formally request that the California Fish and Game Commission (Commission) reclassify the listing of the delta smelt (*Hypomesus transpacificus*) from a threatened species to an endangered species under the California Endangered Species Act (CESA), Fish and Game Code §2050-2068.

Under 14 CCR s 670.1(i)(1)(C) a threatened species may be uplisted to endangered if its continued existence throughout all or a significant portion of its range is in serious danger of becoming extinct by any one or any combination of the factors listed in subsection 670.1(i)(1)(A); 1) present or threatened modification or destruction of its habitat; 2) overexploitation; 3) predation; 4) competition; 5) disease; or 6) other natural occurrences or human-related activities.

Petitioners further request that the Commission review whether the species warrants emergency listing, and if so, that the Commission use its authorities to list the species as endangered on an emergency basis. The Commission may adopt a regulation that adds a species to the list of threatened or endangered species at any time if the Commission finds that there is any emergency posing a significant threat to the continued existence of the species (Fish and Game Code §2076.5).

The delta smelt is currently designated as a threatened species under the CESA. However, the recent and continuing population decline and new information published in peer-reviewed literature, and presented at scientific meetings and CALFED Bay-Delta Program workshops described in this petition demonstrate that the species' listing should immediately be changed to endangered – at risk of extinction. Evidence to support the listing change presented in this petition includes: record low population abundance in the last two years; current population levels below the "effective population size" for the species cited by the U.S. Fish and Wildlife Service (USFWS) in their most recent 5-year review (USFWS 2004); evidence for a significant stock recruitment relationship for the species; population viability and extinction risk analyses that indicate that the species is at high risk of extinction (Bennett 2003, 2005); and new information regarding the effects of Delta water exports on delta smelt population abundance. Due to this extreme situation, the threats documented in this petition constitute an emergency.

The Bay Institute is a non-profit organization that works to protect and restore the ecosystems of San Francisco Bay, the Sacramento-San Joaquin Delta, and the rivers, streams, and watersheds tributary to the Estuary, using a combination of scientific research, public education, and advocacy. The Center for Biological Diversity is a nonprofit, science-based environmental advocacy organization that works to protect endangered species and wild places throughout the world through science, policy, education, citizen activism and environmental law. Natural Resources Defense Council is a nonprofit, environmental organization that works to restore the integrity of the elements that sustain life – air, land and water – and to defend endangered natural places. The Bay Institute, Center for Biological Diversity, and Natural Resources Defense Council submit this petition on their own behalf and on behalf of their members and staff, with an interest in protecting the delta smelt and its habitat.

## TABLE OF CONTENTS

Executive Summary . . . . . 1
Notice of Petition . . . . . 4
Table of Contents . . . . . 6

**I. NATURAL HISTORY AND STATUS OF THE DELTA SMELT . . . . . 7**

A. NATURAL HISTORY . . . . . 7
1. *Description* . . . . . 7
2. *Taxonomy* . . . . . 7
3. *Range and Distribution* . . . . . 8
4. *Habitat Requirements* . . . . . 10
5. *Life History* . . . . . 11
6. *Natural Mortality* . . . . . 14

B. CHANGES IN DISTRIBUTION AND ABUNDANCE . . . . . 15
1. *Historic and Current Distribution* . . . . . 15
2. *Historic and Current Abundance* . . . . . 16
3. *Population Trend and Extinction Risk Analysis* . . . . . 18

**II. CRITERIA FOR CALIFORNIA ENDANGERED SPECIES ACT LISTING . 20**

A. THE DELTA SMELT IS A "SPECIES" UNDER THE CESA . . . . . 20

B. THE DELTA SMELT IS ENDANGERED UNDER THE CESA . . . . . 20
1. *Present or Threatened Modification or Destruction of Its Habitat* . . . . . 21
2. *Overexploitation* . . . . . 32
3. *Predation, Competition or Disease* . . . . . 32
4. *Other Natural Occurrences or Human-Related Activities* . . . . . 33
5. *Inadequacy of Existing Regulatory Mechanisms* . . . . . 34

**III. RECOMMENDED MANAGEMENT AND RECOVERY ACTIONS . . . . . 44**

**IV. CONCLUSION . . . . . 47**

**V. SIGNATURE PAGE . . . . . 48**

**VI. LIST OF INDIVIDUALS SUPPORTING THE PETITION . . . . . 49**

**VII. BIBLIOGRAPHY OF LITERATURE CITED . . . . . 51**

# I. NATURAL HISTORY AND STATUS OF THE DELTA SMELT

## A. NATURAL HISTORY

### 1. Description

The delta smelt (*Hypomesus transpacificus*) is a small (50-80 mm in length for most adults), nearly translucent, steely-blue, osmerid fish endemic to the San Francisco Bay/Sacramento-San Joaquin Delta Estuary, in California. The delta smelt was described as follows by Moyle (2002):

> ...slender-bodied fish that typically reach 60-70 mm SL *(standard length; 2.36—2.76 in)*, although a few may attain 120 mm *(4.73 in)* SL. The mouth is small, with a maxilla that does not extend past the mid-point of the eye. The eyes are relatively large; the orbit width contained approximately 3.5-4 times within head length. Small pointed teeth are present on the upper and lower jaws. The first gill arch has 27-33 gill rakers and there are 7 branchiostegal rays. The gill covers lack strong concentric striations. The pectoral fins reach less than two-thirds of the way to the bases of the pelvic fins. There are 8-11 (usually 9-10) dorsal fin rays, 8 pelvic fin rays, 10-12 pectoral fin rays, and 15-19 anal fin rays. The lateral line is incomplete and has 53-60 scales along it. There are 4-5 pyloric caeca. Live fish are nearly translucent and have a steely-blue sheen to their sides. Occasionally there maybe one chromatophore (a small dark spot) between the mandibles, but usually there is none.

### 2. Taxonomy

Delta smelt is one of six species currently recognized in the *Hypomesus* genus (Saruwatari et al. 1997; as cited in Bennett 2005) and genetic analyses have confirmed that it is a well-defined species with a single intermixing population (Stanley et al. 1995; Trenham et al. 1998). Within the genus, delta smelt is most closely related to surf smelt (*H. pretiosis*), a species common along the western coast of North America. In contrast, delta smelt is a comparatively distant relation to the wakasagi (*H. nipponensis*), which was introduced into Central Valley reservoirs in 1959 and is now sympatric with delta smelt in the estuary. Delta smelt and wakasagi can also be distinguished using morphometric and pigmentation characteristics (Moyle 2002).

The U.S. Fish and Wildlife Service (USFWS) has repeatedly concluded the delta smelt is a distinct species: in an October 1991 proposed listing (56 FR 50075 50084), a March 1993 determination of threatened status (58 FR 12854 12864), a January 1994 revised critical habitat determination (59 FR 852 862), a December 1994 critical habitat determination for the species, and a 2004 5-Year Status Review for the species (USFWS 2004).

### 3. Range and Distribution

Delta smelt are restricted to the upper reaches of the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. The species' overall distribution extends from San Pablo Bay upstream to Sacramento on the Sacramento River and Mossdale on the San Joaquin River (Radtke 1966; Moyle et al. 1992; Moyle 2002), with the actual location of the population varying seasonally and with freshwater outflow (Figure 1). The fish are found typically in shallow (<3 m) and/or surface waters in bays, river channels and sloughs, including in the Sacramento River, the Mokelumne River system, the Cache Slough region, the Delta, Montezuma Slough, Suisun Bay, Suisun Marsh, Carquinez Strait, the Napa River, and San Pablo Bay.

Critical habitat for the delta smelt, designated in 1994 (59 FR 65256 65279), encompasses the areas of all water, all submerged lands below ordinary high water, and the entire water column bounded by and contained in Carquinez Strait, Suisun Bay, Goodyear, Suisun, Cutoff, First Mallard and Montezuma Sloughs, and the Sacramento-San Joaquin River Delta (as defined in Section 12220 of the California Water Code). The area designated by USFWS as critical habitat does not encompass all areas within the estuary in which delta smelt have been found in the past or in which they are have been reported in recent years: for example, in most years with high winter and/or spring freshwater outflows, some portion of the delta smelt population spawns in the Napa River and larvae and juveniles rear in San Pablo Bay (including 2006; California Department of Fish and Game [CDFG] 20 mm Survey results, available at http://www.delta.dfg.ca.gov/data/20mm/). Throughout their life cycle, the fish use different areas and habitat types within their critical habitat at different life history stages (Moyle et al. 1992; Bennett 2005; and see Life History below). For spawning, delta smelt require fresh waters as well as suitable substrate for their adhesive eggs (probably rock or submerged vegetation, although spawning microhabitat is unknown; Bennett 2005). Juveniles and sub-adults use brackish water areas in the estuary, which, depending on freshwater outflow conditions, may be located in the Delta, Suisun Bay, or San Pablo Bay.

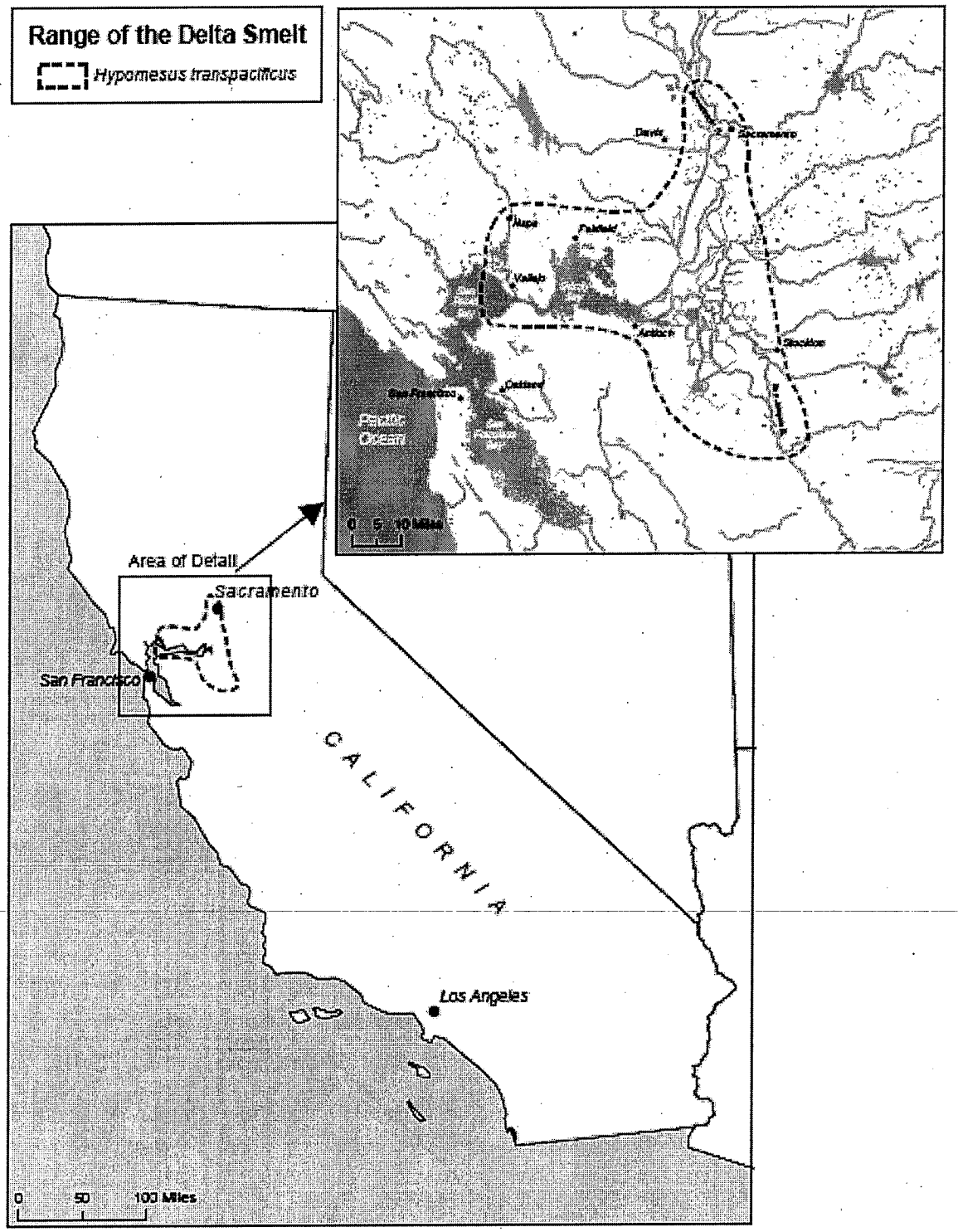


**Figure 1.** Distribution of delta smelt in California's Sacramento-San Joaquin Estuary. Map modified from Bennett 2005.

## 4. Habitat Requirements

Delta smelt are moderately euryhaline (capable of tolerating a wide range of salt water concentrations) and eurythermal (adaptable to a wide range of temperatures). The fish are found generally in brackish water (<10-12 psu [practical salinity units]), a range that corresponds well with measured salinity tolerance limits for the species (0 to 19 psu; Swanson et al. 2000). Except during the winter spawning season, most fish reside in the "low salinity zone" (0.2-2.0 psu; Bennett 2005). Delta smelt tolerate water temperatures from approximately 6°C to 25°C (depending on thermal acclimation history; Swanson et al. 2000). Temperature does not appear to control delta smelt distribution in the estuary, although temperatures >25°C may constrain delta smelt habitat during the summer and early fall (Bennett 2005).

The USFWS (1994) described the specific habitat conditions required by each life stage of delta smelt:

> *Spawning Habitat* - Delta smelt adults seek shallow, fresh or slightly brackish backwater sloughs and edgewaters for spawning. To ensure egg hatching and larval viability, spawning areas also must provide suitable water quality (i.e., low concentrations of pollutants) and substrates for egg attachment (e.g., submerged tree roots and branches and emergent vegetation). Specific areas that have been identified as important delta smelt spawning habitat include Barker, Lindsey, Cache, Prospect, Georgiana, Beaver, Hog, and Sycamore sloughs and the Sacramento River in the Delta, and tributaries of northern Suisun Bay. The spawning season varies from year to year and may start as early as December and extend until July.
>
> *Larval and Juvenile Transport* - To ensure that delta smelt larvae are transported from the area where they are hatched to shallow, productive rearing or nursery habitat, the Sacramento and San Joaquin Rivers and their tributary channels must be protected from physical disturbance (e.g., sand and gravel mining, diking, dredging, and levee or bank protection and maintenance) and flow disruption (e.g. water diversions that result in entrainment and in-channel barriers or tidal gates). Adequate river flow is necessary to transport larvae from upstream spawning areas to rearing habitat in Suisun Bay. Additionally, river flow must be adequate to prevent interception of larval transport by the State and Federal water projects and smaller agricultural diversions in the Delta. To ensure that suitable rearing habitat is available in Suisun Bay, the 2 ppt isohaline must be located westward of the Sacramento-San Joaquin River confluence during the period when larvae or juveniles are being transported, according to the historical salinity conditions which vary according to water-year type. Reverse flows that maintain larvae upstream in deep-channel regions of low productivity and expose them to entrainment interfere with those transport requirements. Suitable water quality must be

provided so that maturation is not impaired by pollutant concentrations. The specific geographic area important for larval transport is confined to waters contained within the legal boundary of the Delta, Suisun Bay, and Montezuma Slough and its tributaries. The specific season when habitat conditions identified above are important for successful larval transport varies from year to year, depending on when peak spawning occurs and on the water-year type. The Service identified situations in the biological opinion for the delta smelt (1994) where additional flows might be required in the July-August period to protect delta smelt that were present in the south and central Delta from being entrained in the State and Federal project pumps, and to avoid jeopardy to the species. The long-term biological opinion on CVP-SWP operations will identify situations where additional flows may be required after the February through June period identified by EPA for its water quality standards to protect delta smelt in the south and central Delta.

*Rearing Habitat*- Maintenance of the 2 ppt isohaline according to the historical salinity conditions described above and suitable water quality (low concentrations of pollutants) within the Estuary is necessary to provide delta smelt larvae and juveniles a shallow, protective, food-rich environment in which to mature to adulthood. This placement of the 2 ppt isohaline also serves to protect larval, juvenile, and adult delta smelt from entrainment in the State and Federal water projects. An area extending eastward from Carquinez Strait, including Suisun Bay, Grizzly Bay, Honker Bay, Montezuma Slough and its tributary sloughs, up the Sacramento River to its confluence with Three Mile Slough, and south along the San Joaquin River including Big Break, defines the specific geographic area critical to the maintenance of suitable rearing habitat. Three-Mile Slough represents the approximate location of the most upstream extent of tidal excursion when the historical salinity conditions described above are implemented. Protection of rearing habitat conditions may be required from the beginning of February through the summer.

*Adult Migration* - Adult delta smelt must be provided unrestricted access to suitable spawning habitat in a period that may extend from December to July. Adequate flow and suitable water quality may need to be maintained to attract migrating adults in the Sacramento and San Joaquin River channels and their associated tributaries, including Cache and Montezuma sloughs and their tributaries. These areas also should be protected from physical disturbance and flow disruption during migratory periods.

### 5. Life History

The life history of delta smelt has been extensively described by Moyle et al. (1992), Moyle (2002), Bennett (2005), and the most recent Biological Opinion for the species (USFWS 2005). Briefly, delta smelt is an annual species although there is evidence that, at least in some years, a small percentage of the population (<10%) survives to two years and may spawn in one or both years (Bennett 2005). Compared to other annual species,

delta smelt exhibit relatively low fecundity with most females producing fewer than 3,000 eggs (Bennett 2005; Mager 1996). Spawning occurs in fresh water during the winter and spring (February-June; peak spawning April-May) and at water temperatures between 12°C and 18°C, with the larger adults maturing, arriving in the Delta, and spawning earlier (i.e., February-April) and at cooler temperatures than smaller, younger fish (Bennett et al. 2006; Herbold et al. 2006). Hatching occurs approximately 8-14 days later depending on water temperature. Newly hatched larvae are small (4.5-6 mm) and, after yolk-sac absorption and development of the jaw and mouth parts, they begin feeding on unicellular algae, rotifers, and/or sub-adult copepods. As the fish grow, their diet shifts nearly exclusively to copepods. Larval and juvenile fish move and/or are transported by flow and tides downstream from freshwater areas in the upper Delta (and, in some years, the Napa River and upper Suisun Marsh) to the brackish low-salinity zone where they rear for the summer and fall. In late fall and early winter, maturing adults begin their diffuse upstream migration to freshwater spawning areas.

Delta smelt exhibit a significant stock recruitment relationship. Using data from California Department of Fish and Game (CDFG) surveys that measure the abundance of juvenile and sub-adult/adult delta smelt (see Historic and Current Abundance, below), correlation and regression analyses show that the abundance of juvenile fish is significantly and directly related to the abundance of the adults that produced them (Figure 2 and Equation 1).[1]

[1] Population abundance of delta smelt is monitored by two California Department of Fish and Game surveys. The Summer Tow Net Survey (TNS), conducted during June and July, measures the abundance of juvenile delta smelt. The Fall Mid Water Trawl (FMWT), conducted from September to December, surveys sub-adult and adult delta smelt. From each of these surveys, delta smelt population abundance is calculated as an annual abundance "index". Because the FMWT and TNS abundance index data are not normally distributed, for these and other statistical analyses, the indices were $\log_{(10)}$ transformed (similar to the approach used by Bennett 2005).

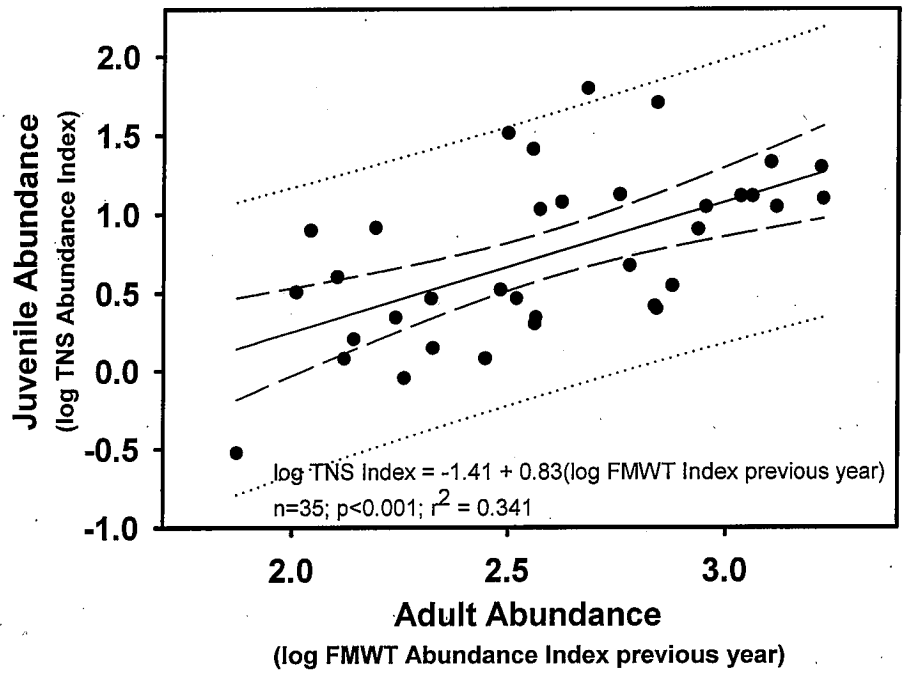


**Figure 2.** The relationship between the abundance of juvenile delta smelt (log TN Index) and the abundance of the adult fish that produced them (log FMWT Index for the previous year). Data are for 1969 to 2005. Regression equation and associated statistics are shown with the graph and are provided in the text. Data source: California Department of Fish and Game.

Log TNS Index = -1.41 + 0.83(log FMWT Index previous year) **(Equation 1)**
$n=35$; $p<0.001$; $r^2=0.341$
where: log TNS Index is abundance of juvenile delta smelt; and
log FMWT Index is the abundance of sub-adult/adult delta smelt.

Similarly, the abundance of adult fish measured the following fall is significantly and directly related to the abundance of the population as juveniles measured earlier in the year (Figure 3 and Equation 2).

Log FMWT Index = 2.21 + 0.46(log TNS Index) **(Equation 2)**
$n=35$; $p<0.001$; $r^2=0.337$

There is considerable disagreement among experts regarding the possible influence of density dependence (i.e., regulation of the size of the population by mechanisms that are themselves controlled by the size of that population, such as availability of food resources) on delta smelt population dynamics and abundance. Bennett (2003, 2005) suggested that the abundance of adult fish might be limited by density dependent effects on juveniles. The CDFG (2003) disagreed in their comment letter to the USFWS for the recent 5-year status review for delta smelt (USFWS 2004), citing lack of credible mechanism(s), the recent low abundance of delta smelt, and the weakness of the statistical evidence for density dependence. The fact that delta smelt are not currently abundant relative to their recent past abundance or relative to the other species living in

the Delta suggests that the species has not exceeded the carrying capacity of its habitat and that its abundance is not limited by density dependent effects. Regardless, Bennett's (2005) analysis indicated that, since the early 1980s, density dependent effects did not occur at population abundance levels lower than 400-450 (as measured by the Fall Water Trawl Abundance Index; and see Historic and Current Abundance below), levels that are roughly comparable to or somewhat lower than the recovery criteria identified for the species (Moyle et al.1996).

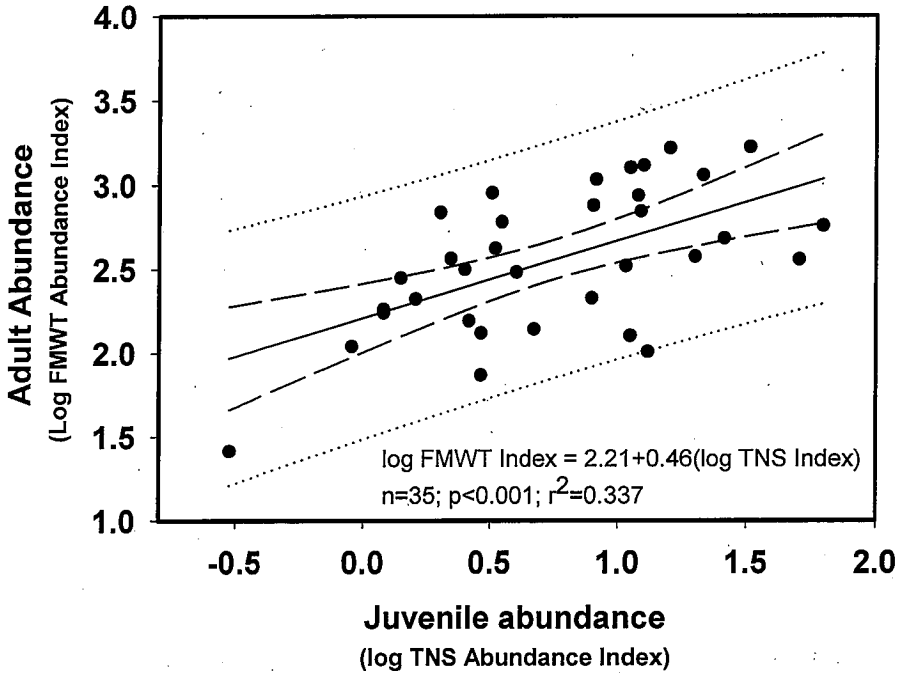


**Figure 3.** The relationship between the abundance of adult delta smelt (log FMWT Index) and the abundance of juvenile measured earlier in the same year (log TNS Index). Data are for 1969 to 2005. Regression equation and associated statistics are shown with the graph and are provided in the text. Data source: California Department of Fish and Game.

### 6. Natural Mortality

The most recent review of delta smelt status reports that there is insufficient evidence for effects of disease, competition or predation on delta smelt population abundance (USFWS 2004). However, diseases and parasites of delta smelt have not been well studied and numerous introduced species are abundant in the estuary. Competition and predation by introduced species has been shown to affect delta smelt size and condition (Souza et al. 2005; Teh 2005) but its role in affecting delta smelt population abundance has not been quantified (see discussion of Disease, Competition, or Predation below).

## B. CHANGES IN DISTRIBUTION AND ABUNDANCE

### 1. Historic and Current Distribution

**Historic distribution**: The delta smelt's historic distribution extended from San Pablo Bay upstream to Sacramento on the Sacramento River and Mossdale on the San Joaquin River (Radtke 1966; Moyle et al. 1992; Moyle 2002), with the actual location of the population varying seasonally and with freshwater outflow. Based on results of CDFG sampling surveys for juveniles during the Summer Townet Survey (TNS) and adults during the Fall Mid Water Trawl (FMWT) survey conducted since the late 1950s as well as earlier published reports (cited in the references above), delta smelt were found in shallow (<3 m) and/or surface waters in bays, river channels and sloughs, including in San Pablo Bay, Carquinez Strait, the Napa River, Suisun Bay, Suisun Marsh, Montezuma Slough, the Sacramento River, the Cache Slough region, the Mokelumne River system, the San Joaquin River, Old and Middle Rivers, and all other channels and sloughs in the Delta with accessible subtidal, shallow-water habitat. In general, the rivers, channels, and sloughs in the Delta function as both rearing habitat for larval and juvenile delta smelt and a migration corridor for both the adult and juvenile life stages while the brackish, open bay areas serve as rearing habitat for older juveniles and sub-adult delta smelt (see Habitat Requirements and Life History).

**Current distribution**: Since the late 1970s, large areas of historic delta smelt habitat (and designated critical habitat) within the Delta have been degraded for a key life history stage of the species: the distribution of the species has been substantially reduced. Based on results from the summer TNS, which has been conducted annually since 1959, juvenile delta smelt have virtually disappeared from the Delta in areas south of the San Joaquin River (Miller 2000; CDFG 2003; Fleming and Nobriga 2004). Most of the environmental characteristics of these south Delta channels and sloughs known to be necessary for the species (e.g., temperature, salinity, water depth) have not changed. Recent surveys for adult delta smelt (CDFG Spring Kodiak Trawl) and larvae (CDFG 20 mm Survey) indicate that this region of the Delta is still used for spawning in the spring. But, by two to three months later, few or no juvenile delta smelt are collected during the summer TNS, a marked change compared to results of the first 20 years of the survey. This is the region of the Delta most directly affected by State Water Project (SWP) and Central Valley Project (CVP) water export operations and by the installation and spring-summer operations of three south Delta tidal gate barriers designed to maintain water levels and water quality for local agricultural water diverters. The period during which juvenile delta smelt disappeared from this portion of their historic habitat (i.e., the late 1970s) coincides with substantial increases in the amounts of water exported, increases in frequency of high volume export operations, and the initiation and increasing duration of south Delta barrier operations (Simi and Ruhl 2005; Fleming and Nobriga 2004; and see Figure 4).

Recent analyses by scientists with the California Department of Water Resources (CDWR) indicate that overall habitat quality and the area of habitat in the estuary suitable for delta smelt have declined during the past fifteen years (Feyrer et al. 2005, 2006).

Using water temperature, salinity, turbidity and delta smelt catch data from the CDFG's FMWT survey, the authors constructed a "habitat quality" index that related those environmental factors to the presence of delta smelt. Their results showed a long-term decline in fall habitat quality since the early 1990s and a more recent, sharp decline in the 2000s, coincident with the recent precipitous decline in the delta smelt population (see Historic and Current Population Abundance). The decline in habitat quality was driven by reduced freshwater outflows and resultant increased salinity in the western Delta.

### 2. Historic and Current Abundance

More than a dozen regular surveys collect data on delta smelt within the estuary (USFWS 2004) but the population abundance estimates used for most analyses and for tracking the species' population status are calculated from results of two surveys conducted by the CDFG: the TNS which samples juvenile delta smelt and the FMWT which samples sub-adult and adult delta smelt. From each survey, an abundance index is calculated by extrapolating the numbers of fish caught at 30 to 80 fixed stations, using a weighting factor that accounts for differences in water volume at various sub-regions from San Pablo Bay through the Delta (Bennett 2005). A subset of stations and months from the FMWT is also used to calculate the Recovery Index (Moyle et al.1996). None of these indexes provide direct measurements of actual population abundance. However, total population size calculated from the raw survey data and habitat volume estimates by Bennett (2005) show a good linear correspondence with the abundance indices, suggesting that the indices represent reasonable estimates of relative population abundance.

**Historic abundance:** As recently as 30 years ago, delta smelt was one of the most common and abundant of the pelagic fishes caught in the estuary, as indicated by its abundance in CDFG trawl catches (Erkkila et al. 1950; Radtke 1966; Stevens and Miller 1983). For the first 16 years of the FMWT survey (1967-1982), the most comprehensive survey for the species, the abundance index averaged 806, a value that roughly corresponds to an estimated 800,000 adult fish (Bennett 2005). But, in the early 1980s, the population declined by more than 80% (based on the FMWT Index; the decline was 95% based on the TNS Index; Table 1 and Figure 4). According to Bennett (2005) this precipitous decline was the result of the combination of extremely high winter and spring outflows, elevated springtime water temperatures and resultant short duration spawning periods, and two consecutive years of extremely high levels of incidental take at the SWP and CVP water export facilities. From 1983 through 1992, delta smelt abundance (measured as the FMWT Index) was consistently low, averaging just 33% of the 1967-1982 average abundance levels. In 1993, abundance increased considerably and, throughout the rest of the decade, population levels fluctuated but were, on average, roughly double those measured during the 1983-1992 period (Table 1). This increase prompted several stakeholder groups to challenge the listing, an action that ultimately led to the recent 5-year status review for the species (USFWS 2004).

**Table 1.** Abundance of delta smelt as measured by the CDFG Summer Tow Net Survey (TNS, juvenile delta smelt), Fall Mid Water Trawl Survey (FMWT, adult delta smelt), and the Recovery Index (based on FMWT data, adult delta smelt). NA= abundance index not yet available.

| Year | TNS Index | FMWT Index | FMWT averages | Recovery Index | Comments |
|---|---|---|---|---|---|
| 1959 | 12.1 | | | | Comparisons are based on FMWT Indices |
| 1960 | 25.4 | | | | |
| 1961 | 21.3 | | | | |
| 1962 | 24.9 | | | | |
| 1963 | 1.8 | | | | |
| 1964 | 24.6 | | | | |
| 1965 | 6.0 | | | | |
| 1966 | no data | | | | |
| 1967 | no data | 414 | 1967-1982: 806 | 139 | |
| 1968 | no data | 696 | | 251 | |
| 1969 | 2.5 | 315 | | 128 | |
| 1970 | 32.5 | 1673 | | 598 | |
| 1971 | 12.5 | 1303 | | 352 | |
| 1972 | 11.1 | 1265 | | 551 | |
| 1973 | 21.3 | 1145 | | 305 | |
| 1974 | 13.0 | no data | | no data | |
| 1975 | 12.2 | 697 | | 239 | |
| 1976 | 50.6 | 360 | | 22 | |
| 1977 | 25.8 | 481 | | 146 | |
| 1978 | 62.5 | 572 | | 108 | |
| 1979 | 13.3 | no data | | no data | |
| 1980 | 15.8 | 1653 | | 312 | |
| 1981 | 19.8 | 374 | | 78 | |
| 1982 | 10.7 | 330 | | 37 | |
| 1983 | 2.9 | 132 | 1983-1992: 267 | 17 | Population declines 84% (from 1967-1982 FWMT). |
| 1984 | 1.2 | 182 | | 51 | |
| 1985 | 0.9 | 110 | | 29 | |
| 1986 | 7.9 | 212 | | 70 | |
| 1987 | 1.4 | 280 | | 72 | |
| 1988 | 1.2 | 174 | | 67 | |
| 1989 | 2.2 | 366 | | 76 | |
| 1990 | 2.2 | 364 | | 81 | |
| 1991 | 2.0 | 689 | | 171 | |
| 1992 | 2.6 | 156 | | 26 | |
| 1993 | 8.2 | 1078 | 1993-2001: 572<br>1999-2001: 741 | 400 | Delta smelt listed as threatened |
| 1994 | 13 | 102 | | 19 | Abundance is 9% of 1993 level. |
| 1995 | 3.2 | 899 | | 252 | Abundance is 83% of 1993 level. |
| 1996 | 11.1 | 127 | | 28 | Abundance is 12% of 1993 level. |
| 1997 | 4.0 | 303 | | 62 | Abundance is 28% of 1993 level. |
| 1998 | 3.3 | 420 | | 169 | Abundance is 39% of 1993 level. |
| 1999 | 11.9 | 864 | | 322 | Abundance is 80% of 1993 level. |
| 2000 | 8 | 756 | | 265 | Abundance is 70% of 1993 level. |
| 2001 | 3.5 | 603 | | 314 | Abundance is 56% of 1993 level. |
| 2002 | 4.7 | 139 | | 33 | Population declines 81% (from 1999-2001 FWMT). Abundance is 13% of 1993 level. |
| 2003 | 1.6 | 210 | | 101 | Some recovery criteria met (this year only). Abundance is 19% of 1993 level. |
| 2004 | 2.9 | 74 | | 25 | Abundance is 7% of 1993 level. |
| 2005 | 0.3 | 26 | | 4 | Abundance is 3% of 1967-1982 average, 4% of 1999-2001 average, and 2% of 1993 level. |
| 2006 | 0.4 | 41 | | 21 | Abundance is 5% of 1967-1982 average, 6% of 1999-2001 average, and 4% of 1993 level. |

**Current abundance:** In 2002, the delta smelt population again experienced a drastic population decline, dropping more than 80% from levels measured during the previous three years (1999-2001 average) (based on the FMWT Index; the decline was 77% based on the 2003 TNS Index compared to the 1999-2002 average; Table 1 and Figure 4). Since then, the population has continued to decline, falling to what was then a record low in 2004 (FMWT=74, or an estimated 60,000-70,000 adult fish) and then plummeting again by 65% to a FMWT Index of just 26 in 2005, the lowest abundance level ever recorded for sub-adult and adult delta smelt. The recently released 2006 FMWT Index, 41, is the second lowest level measured during the 40-year survey. Based on Bennett's (2005) analyses, the 2006 FMWT Index roughly corresponds to fewer than 35,000 adult fish.

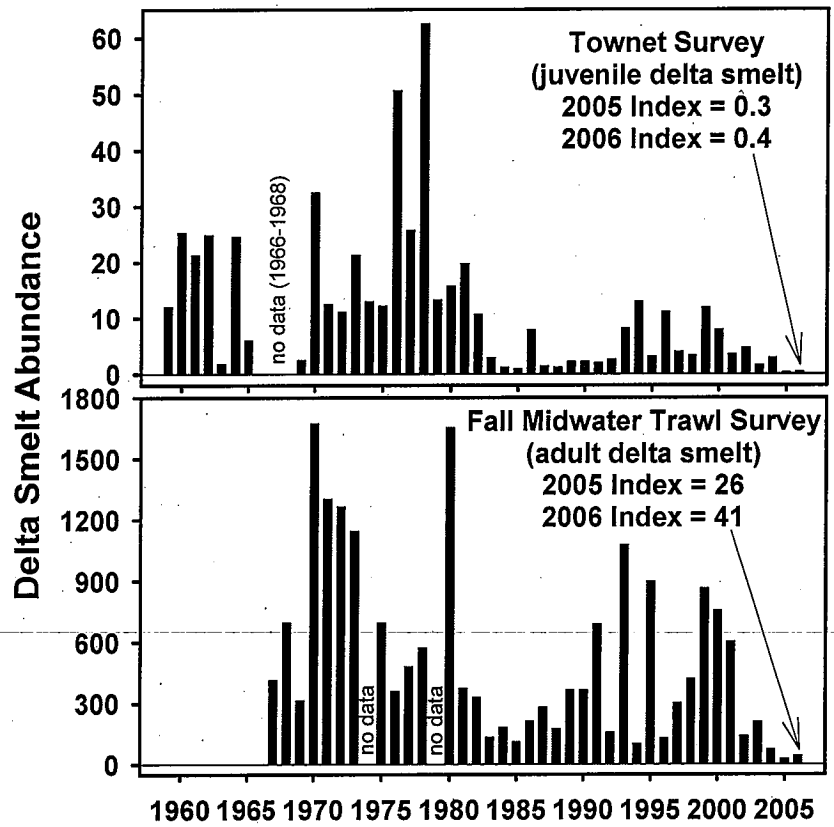


**Figure 4.** Trends in abundance of delta smelt as measured by two different surveys. The upper panel shows the abundance index calculated from the Summer Townet Survey (TNS, 1959-2006), which samples juvenile delta smelt. The lower panel shows the abundance Index calculated from the Fall Midwater Trawl Survey (FMWT, 1967-2006), which samples sub-adult and adult delta smelt. Data source: California Department of Fish and Game.

### 3. Population Trend and Extinction Risk Analysis

By the time the delta smelt was listed as threatened in 1993, the species had experienced a decade of chronically low population abundance followed by the beginnings of an apparent recovery, with both juvenile and adult abundance indices increasing (Table 1

and Figure 4). In 1993, delta smelt abundance was the highest measured since the major population decline in the early 1980s. During the rest of the 1990s, abundance fluctuated but generally continued to improve. This period corresponded with favorable water temperature and flow conditions. The most recent population decline began in 2000 and, in 2002, abundance of adult delta smelt dropped by more than 75% compared to the previous year. The following year, abundance of the juvenile fish was 66% lower than that measured in the previous year. Since then, population abundance as measured by both life-stage specific surveys has continued to decline. By 2005, abundance of juvenile delta smelt was just 3.7% of that measured in 1993 when the species was listed under the CESA and the abundance of adult delta smelt was just 2.4% of the 1993 level. Abundance levels measured in 2006 showed no signs of meaningful improvement.

Using data on past measured population abundance and variability, Bennett (2003, 2005) conducted a population viability analysis for delta smelt, calculating probabilities and predicted time frames for extinction of the species.[2] In the first step of his analysis, Bennett (2003) estimated the delta smelt population would be below its "effective population size", the population level below which a species is subject to inbreeding and genetic drift, if the FMWT Index fell below 100 for two consecutive years. At the time of this analysis, this abundance level was similar to the lowest FMWT Index ever measured for the species (1994 FMWT Index of 102, or an estimated 86,203 adult fish). The USFWS 5-year status review (2004) recognized this definition of an effective population size and noted that this population size reflected an "unprecedented low number of delta smelt." Based on this analysis, the current delta smelt population has been well below its effective population size for the past three consecutive years, with the 2004, 2005 and 2006 FMWT Index values of 74, 26 and 41 respectively (Table 1).

Using the now defined effective population size as a benchmark, Bennett (2003, 2005) then conducted an extinction risk analysis using three progressively more extreme population size criteria to simulate extinction: 80,000, 8,000, and 800 fish. For each population level, the analysis used FMWT data for the 1982-2003 period to calculate the median time to a 50% probability of extinction and the probability that extinction would occur within 20 years. For the highest population level, the analysis predicted that the median time to when there was a 50% chance that the population would fall below 80,000 fish was only 1.2 to 1.5 years, a statistic confirmed one year later when the FMWT Index fell to 74. Using the lower extinction levels, Bennett (2005) predicted that the median time to 50% probability of extinction defined as a population size of just 8,000 fish was only 20 years and, for a population size of 800 fish, 42 to 55 years. For this lowest extinction level (800 fish), there was a 26-30% probability that extinction would occur within 20 years. Bennett (2005) compared his results to criteria developed by the International Union for Conservation of Nature and Natural Resources, which defines an endangered species as one with a 20% probability of extinction in 20 years, and concluded that "delta smelt qualifies for Endangered ... status" (page 55).

[2] Another extinction probability analysis conducted by the San Luis & Delta-Mendota Water Authority (2002) was considered by the USFWS in their 5-year review (USFWS 2004). However, independent peer-review of this analysis by USGS (2003) concluded that this extinction probability analysis and estimate was seriously flawed.

## II. CRITERIA FOR CALIFORNIA ENDANGERED SPECIES ACT LISTING

### A. THE DELTA SMELT IS A "SPECIES" UNDER THE CESA

The Delta smelt is indisputably a species, as discussed in the section on taxonomy above. The California Fish and Game Commission acknowledged the delta smelt is a distinct species in the state threatened listing of December 1993. The USFWS has also concluded the delta smelt is a distinct species in the October 1991 proposed federal listing (56 FR 50075 50084), a March 1993 determination of threatened status (58 FR 12854 12864), a January 1994 revised critical habitat determination (59 FR 852 862), a December 1994 critical habitat determination for the species, and a 2004 5-year status review for the species (USFWS 2004).

### B. THE DELTA SMELT IS ENDANGERED UNDER THE CESA

The CESA defines an "endangered species" as "a native species or subspecies of a bird, mammal, fish, amphibian, reptile, or plant which is in serious danger of becoming extinct throughout all, or a significant portion, of its range due to one or more causes, including loss of habitat, change in habitat, overexploitation, predation, competition, or disease" (Fish and Game Code §2062). The threats to a species' survival are categorized according to the CESA as:

(1) Present or threatened modification or destruction of its habitat;
(2) Overexploitation;
(3) Predation;
(4) Competition;
(5) Disease; or
(6) Other natural occurrences or human-related activities.

According to the USFWS 5-year status review (USFWS 2004), there are sufficient data and analyses available to identify (1) present or threatened modification or destruction of habitat and (6) other natural occurrences or human-related activities as present and ongoing threats to the species. Additionally, the delta smelt is threatened with extinction by the inadequacy of current regulatory mechanisms and management efforts. In their recent 5-year status review for the species, the USFWS (2004) concluded that for delta smelt, "most threats which were discussed in the original listing remain." In this petition to list delta smelt as endangered under the CESA, we concur with the USFWS conclusion and we add new analyses and information to demonstrate that the nature, degree, and increasing severity of the threats of modification or destruction of habitat and the inadequacy of existing regulatory mechanisms to protect the species, arrayed against a dramatically reduced delta smelt population, combine to place the species in severe and immediate danger of extinction throughout its range.

Delta smelt are environmentally sensitive because they have a short life span, have a limited diet, have a low fecundity for a fish producing planktonic larvae, are poor swimmers, are easily stressed, and reside primarily in the interface between salt and fresh water within a limited geographic extent. In addition to these characteristics, the species

is highly vulnerable to extinction because of its present small population size. As noted by Moyle (2002), a substantial population is necessary to keep delta smelt from becoming extinct, and the species has recently fallen below the effective population size for viability (as defined by Bennett 2003) to an "unprecedented low number of delta smelt" (USFWS 2004). Multiple factors are thought to be contributing to the continuing population decline of the species, including: reductions in freshwater inflows and outflows to the estuary; direct and indirect adverse impacts of Delta water diversions and exports; effects of water management operations on estuarine habitat quality; reductions in abundance of prey food organisms; lethal, sub-lethal and indirect effects of toxic substances; disease, competition, and predation; and loss of genetic integrity. The magnitude and frequency of occurrence of most of these factors are increasing and current regulatory protections for the species and its habitat are clearly inadequate

The delta smelt indisputably merits immediate emergency listing under the CESA as an endangered species. The factors threatening the continued survival of the delta smelt are detailed below.

### 1. Present or Threatened Modification or Destruction of Its Habitat

Delta smelt reside entirely within the estuary, confined to a relatively small geographic range of low salinity and freshwater habitat. For some life history stages, the species is restricted to even smaller subregions within the estuary (e.g., the Delta for spawning in most years). Delta smelt live in the water column and, in their movements within their habitat, they often move "with the flow". For delta smelt, water is habitat. Therefore changes in the timing and amounts for freshwater inflow and outflow to and from the estuary, water export regimes, in-Delta hydrodynamics, water quality, and the estuarine food web have direct and significant impacts on the species.

The Delta, the heart of delta smelt spawning and early rearing habitat, is a major hub for California's water management system and a region of intensive irrigated agriculture. Water management operations of the massive SWP and the federal CVP in the Delta and its Sacramento and San Joaquin River watersheds have had major and often detrimental effects on freshwater inflow to the Delta, in-Delta hydrodynamics, freshwater outflow from the Delta, and water quality. For example, during periods of low freshwater inflow and high volume water exports, conditions that are common during periods when the bulk of the delta smelt population is distributed in the Delta, as much as 65% of the total freshwater inflow may be diverted, and net movement of water and entrained plankton, larvae and small fish in the central and southern Delta is towards the export facilities. At times, the net flows of the lower San Joaquin River in the Delta and several other important Delta channels are reversed, confusing and delaying migrating adult fish, impairing downstream transport of larval and juvenile delta smelt from the upper estuary where they were spawned to their brackish water rearing habitat, and lethally entraining large numbers of larval, juvenile, and adult delta smelt into state, federal, and local water diversions. The fish screens at the SWP and CVP fish facilities are known to be inadequate for protection of delta smelt (as well as for most other species; e.g., Bowen et al. 2004). Despite evidence of the limited effectiveness of these facilities for fish

protection, and evidence that this effectiveness is further deteriorating (Bowen et al. 2004), plans to upgrade or replace the facilities have been delayed indefinitely (SDFFF 2005).

Freshwater Inflows and Outflows

The Sacramento-San Joaquin Delta Estuary is a highly managed system: for much of most years, freshwater flows into the Delta from the estuary's largest tributaries, the Sacramento and San Joaquin Rivers, and freshwater outflows from the Delta are precisely managed by the federal and state water projects to support water export demands while minimally meeting water quality and outflow standards mandated by the California State Water Resources Control Board (SWRCB 1995). Historically, the San Joaquin River provided 21% of the total freshwater inflow to the Delta (based on data from the CDWR). In recent years, freshwater inflows from this river have declined substantially, averaging just 10% during the 2001-2005 period, with consecutive record low freshwater inflows in 2003 (6.4%) and 2004 (6.2%). Recent research by scientists from the U.S. Geological Survey (USGS) has shown that low San Joaquin River inflows, in combination with high water export rates, disrupt in-Delta tidal exchange and flows, cause negative (or "reverse") flows in important Delta channels such as the lower San Joaquin River, Old River and Middle River, and result in nearly all water and small pelagic organisms (such as delta smelt) in the central and southern Delta being drawn inexorably to the SWP and CVP pumps (Simi and Ruhl 2005; Ruhl et al. 2006). These researchers also showed that low San Joaquin River inflows, negative flows on Old and Middle Rivers, and high exports were significantly related to high levels of incidental take of delta smelt at the SWP and CVP facilities (see Water Exports and Diversions below), and that the frequency of occurrence of these conditions had increased during the past two decades.

New analyses by scientists from the Contra Costa Water District have demonstrated the negative effects of reduced freshwater outflows on delta smelt population abundance. Guerin et al. (2006) showed that reduced freshwater outflows during the fall, and resultant increases in western Delta salinity, significantly corresponded to reduced population abundance of juvenile delta smelt measured by the CDFG TNS the following year (Figure 5). Given the significant stock recruitment relationship for delta smelt (see Figure 2), these researchers further improved this statistical model for juvenile delta smelt abundance by inclusion of information on the size of the adult population that produced them. Equation 3 shows the multiple regression model for predicting the abundance of juvenile delta smelt based on western Delta salinity and the FMWT Abundance Index measured the previous fall.[3] Guerin et al. (2006) also reported that the frequency of occurrence of reduced fall freshwater outflows and elevated salinity in the western Delta had increased during the past ten years.

[3] Guerin et al. (2006) used untransformed TNS and FMWT Abundance Indices in their analyses. Because the FMWT and TNS abundance index data are generally not normally distributed, we have repeated their analyses using $\log_{(10)}$ transformed data (as with Equations 1 and 2, and similar to the approach used by Bennett 2005).

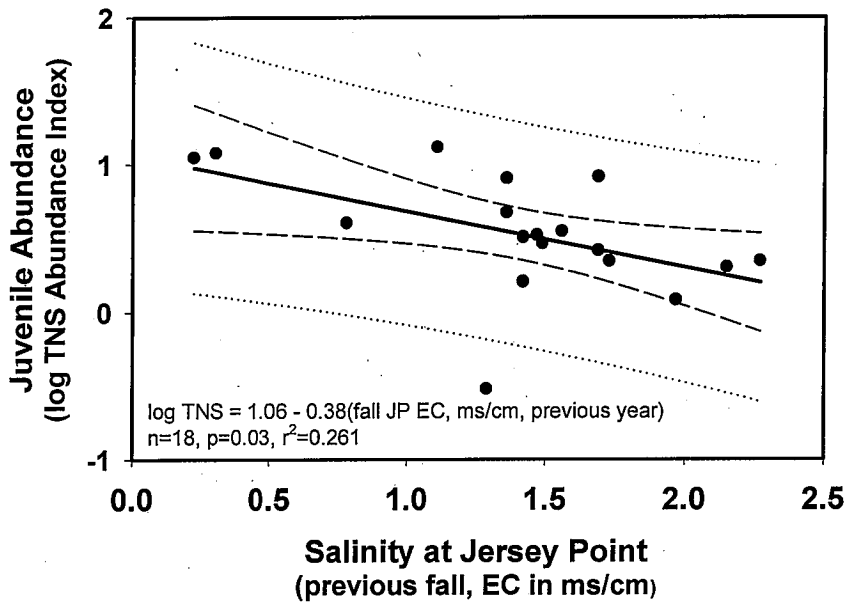


**Figure 5.** The relationship between fall salinity in the western Delta (Jersey Point EC [ms/cm], Oct.-Dec.) and abundance of juvenile delta smelt measured the following year (log TNS Abundance Index). Data are for 1988-2005. Regression equation and associated statistics, 95% confidence limits and the prediction limits are shown with the graph. A multiple regression model for this relationship that incorporates an additional variable is shown below in the text (Equation 3). Data sources: California Department of Fish and Game, Contra Costa Water District.

Log TNS Index =
-0.535 - 0.297(JP EC, prev. fall) + 0.593(log FMWT Index prev. year) **(Equation 3)**
n=18; p=0.004; $r^2$=0.522
where: log TNS Index is abundance of juvenile delta smelt;
JP EC is salinity (ms/cm) at Jersey Point (Oct.-Dec.) measured the previous year; and
log FMWT Index is the abundance of sub-adult/adult delta smelt measured the previous year.

These analyses indicate that seasonally reduced freshwater inflows and elevated salinity in Suisun Bay and the western Delta adversely alter delta smelt habitat (a conclusion also reached by Feyrer et al. [2005, 2006] using a different analytical approach; see Historic and Current Distribution). These conditions are related to establishment and increased abundance of the invasive clam, *Corbula amurensis*, in upper Suisun Bay and the western Delta measured in recent years (Thompson and Parchaso 2006). The negative impact of this invasive filter-feeder on the estuarine planktonic food web upon which delta smelt depends is well documented (Kimmerer and Orsi 1996; Thompson and Parchaso 2006).. In addition, reduced freshwater outflows and the consequent shift of the low salinity habit preferred by delta smelt further upstream increases the proximity and vulnerability of the fish to lethal entrainment at state, federal, industrial, and agricultural water diversions (Herbold et al. 2006). Guerin et al. (2006) suggested that both of these ecosystem

responses were potential mechanisms driving the relationship between reduced freshwater outflows and reduced delta smelt population abundance.

Water Exports and Diversions

In addition to the SWP and CVP water export facilities, more than 1,800 smaller diversions extract water for local consumptive use, and two power plants use Delta water for cooling (Herren and Kawasaki 2001). The USFWS (2004) concluded that the power plants at Pittsburg and Antioch, which use flow-through cooling and are located within the region of seasonal maximum abundance of delta smelt, can impose significant mortality on delta smelt. Fish screens at the SWP and CVP export facilities are known to be inadequate to protect delta smelt (Bowen et al. 2004) and the vast majority of the other Delta diversions are unscreened (Herren and Kawasaki 2001).

Water exports and diversions adversely affect delta smelt directly by entrainment (i.e., movement of fish due to the hydraulic effects of pumping and lethal removal of the fish from its habitat through unscreened or inadequately screened water diversions) or impingement (getting stuck on fish or debris screens at pumps); and indirectly by adversely modifying their critical habitat (e.g., by altering in-Delta hydrodynamics, reducing freshwater outflow and shifting the location of suitable low salinity rearing habitat, and/or removing planktonic food organisms). The species is at greatest risk from water diversions at two critical times in its life cycle, first as larvae and juveniles when the young fish move downstream to low salinity rearing habitat (spring and early summer) and then again as pre-spawning and spawning adults when maturing fish move up into the Delta for reproduction (winter and early spring). All of these life stages are known to be lethally entrained at government, urban, industrial, and agricultural diversions in the Delta (e.g., Matica and Sommer 2005; Nobriga et al. 2002; Moyle 2002). A portion of the entrainment loss of delta smelt >20 mm in length is monitored and reported as incidental take at only the SWP and CVP water export facilities.[4] Incidental take of delta smelt at the other diversions and of larval and juvenile fish <20 mm in length at the government water project facilities is neither monitored nor reported and no effort is made to rescue these fish. Therefore, the incomplete incidental take data are of limited value for evaluating the effects of water export activities on delta smelt population levels, although they do provide useful information on the timing and presence of the fish in the south and central Delta.

[4] Incidental take reported for delta smelt at the state and federal water export facilities is known to be a gross underestimate of the actual numbers of fish lethally entrained. The daily take number is calculated from counts of fish >20 mm in length collected in regular sub-samples of water bypassed through two sequential sets of louvers and/or fish screens. However, efficiency of the louvers to remove delta smelt from the diverted water is known to be low for delta smelt (i.e., under many conditions, more than half of the diverted fish pass through the louvers and are transported uncounted to the pumps; Bowen et al. 2004). Delta smelt larvae and juveniles <20 mm in length are not counted, but the loss of larval and juvenile delta smelt to entrainment is estimated at several million each year (USFWS 2004). In addition, unknown proportions of the fish entrained into the facilities are lost to predation and/or other mortality factors and never reach the fish salvage facilities to be counted.

Since the delta smelt was first listed as threatened under the CESA in 1993, annual water exports from the Delta have increased by more than 25% (1994-1998 average: 4.773 million acre-feet [MAF] per year; 2002-2006 average: 5.992 MAF per year).[5] In 2005, annual water exports reached a new record high of 6.305 MAF. Annual exports for 2006, 6.157 MAF, were the third highest on record. This increase continues a long-term trend of increases in Delta water exports (Figure 6, top panel). During the periods when delta smelt are vulnerable to entrainment, the relative increases in exports have been even greater, with a 49% increase in winter exports (December-March, when pre-spawning and spawning adults are in the Delta, Figure 6, middle panel) and a 30% increase in spring exports (March-July, when larvae and small juveniles are in the Delta, Figure 6, bottom panel).

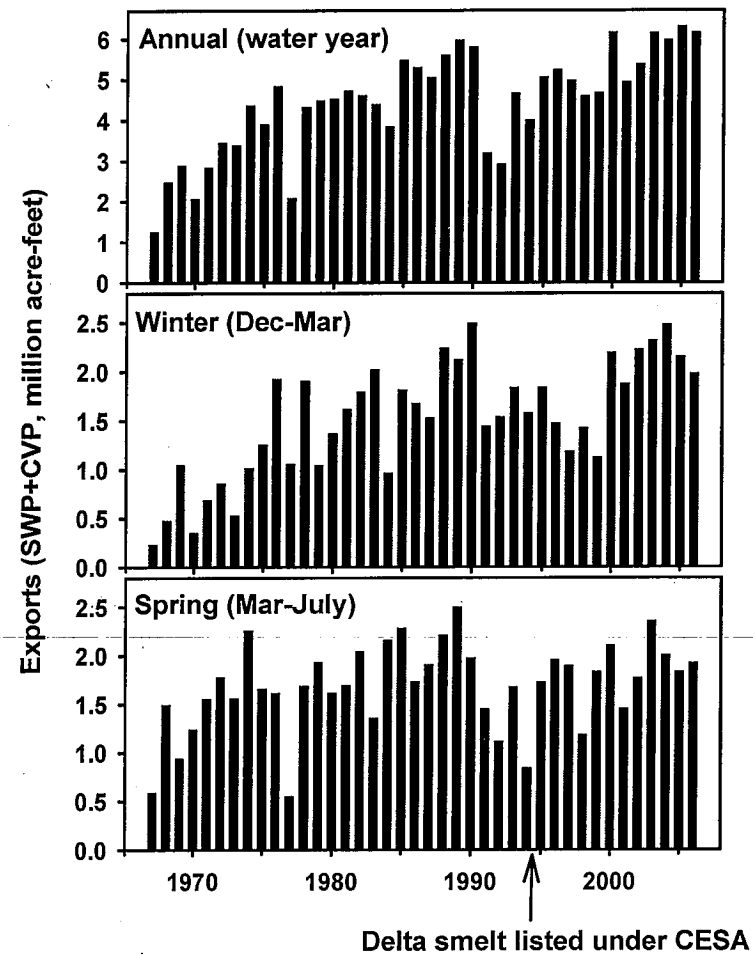


**Figure 6.** Combined water exports (million acre-feet, MAF) of the Central Valley Project and the State Water Project from 1967-2006. The upper panel shows total export volumes for each water year. The middle panel shows exports for the winter period (December-March). The lower panel shows springtime exports (March-July). Data source: California Department of Water Resources, Dayflow.

[5] Exports are calculated as the combined annual total (using the water year calendar) for Central Valley Project and State Water Project exports using data from Dayflow (California Department of Water Resources).

*Direct Impacts*: The CDFG (2003) expressed concern that entrainment of delta smelt at the CVP and SWP could be a major source of population impacts under certain conditions. Data from the summer TNS show an almost complete disappearance of juvenile delta smelt in south Delta sampling stations by the mid-1970s, coincident with a trend of increasing combined water exports from the south Delta (CDFG 2003). CDFG (2003) estimated losses of delta smelt juveniles to SWP and CVP operations to range from 11 to 46% of the population annually.

Analyses conducted by Herbold et al. (2005) as part of the ongoing multi-agency research program to investigate the recent pelagic fish declines in the Delta indicate that the direct impacts of water exports on delta smelt (and other Delta pelagic fish species) during the winter have increased in recent years, coincident with substantial population declines measured for all the affected species.[6] Beginning in 2000, incidental take (also referred to as "salvage") of adult delta smelt increased markedly (Figure 7, top panel), concurrent with substantial increases in exports during the same period (see Figure 6, middle panel). In 2003, direct loss of adult delta smelt at the pumps in relation to the species' population abundance reached its highest level in more than ten years (Figure 7, bottom panel). On the basis of these and other analyses conducted by researchers investigating the pelagic organism decline, the "Winter Adult Entrainment Hypothesis" is one of two leading hypotheses to explain the pelagic fish decline that will be the focus of continuing research in the next two years (Armor et al. 2005, Armor 2006).[7]

Recent analyses by scientists from the USGS have suggested a mechanism for the recent disproportionately high take of delta smelt (and other fish species) at the SWP and CVP facilities (Simi and Ruhl 2005; Ruhl et al. 2006). Using data from the past twenty years, these researchers reported a significant correlation between high incidental take and hydrodynamic conditions in the central and southern Delta caused by low San Joaquin River inflows and high water export rates. Under these conditions, normal tidal exchange and flows are disrupted (with the ebb tidal flow nearly eliminated); flows in two important Delta channels, Old River and Middle River, are negative; virtually all water in the central and southern regions of the Delta is drawn inexorably to the pumps; and incidental take of delta smelt is high. During the past twenty years, the frequency of occurrence of these types of conditions has increased.

[6] Herbold et al. (2005) used the November-March period for their analyses.

[7] In 2005 the Interagency Ecological Program began an intensive research program to investigate the cause(s) of the Pelagic Organism Decline (POD) in the Delta. Preliminary results of this research are available at: http://science.calwater.ca.gov/workshop/workshop_pod.shtml.

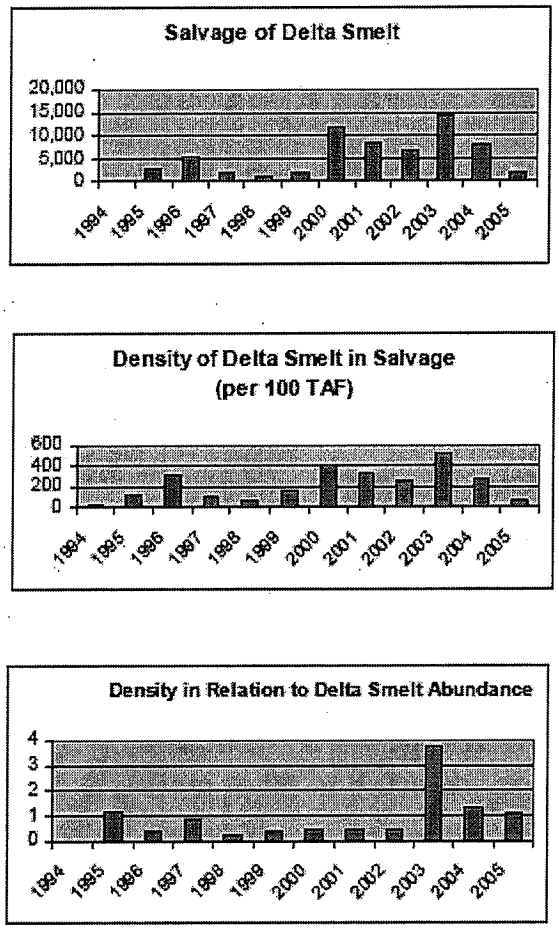


**Figure 7.** Recent patterns in incidental take (or salvage) of delta smelt during the November-March period. Top panel: total salvage (# fish); Middle panel: salvage density (# of fish/thousand acre-feet); and Bottom panel: salvage density in relation to preceding FMWT abundance Index (salvage density/FMWT Index previous year). Source: Herbold et al. 2005, Figure 3.

In addition to the direct effects of export rates on lethal entrainment of delta smelt at the SWP and CVP facilities, anthropogenic changes to Delta channel configuration, circulation and infrastructure have increased diversion-related mortality of delta smelt. During the spring, summer and fall, the CDWR installs and operates four "temporary agricultural barriers" in the south Delta (i.e., the Grant Line Canal, Old River near the Delta Mendota Canal, Middle River, and Head of Old River barriers) for the purpose of maintaining adequate water levels and quality for south Delta agricultural diverters under conditions of low Delta inflow and high SWP and CVP export rates. When these barriers are closed, they physically prevent delta smelt movement (e.g., block downstream migration of juveniles to low salinity habitat in Suisun Bay) and alter south Delta hydrodynamics, increasing central Delta flows toward the state and federal water export facilities (USFWS 2004). According to results of particle tracking modeling analyses conducted by CDWR and USFWS (USFWS 2004), this increases the incidental take of delta smelt at the SWP and CVP as well as lethal entrainment of the fish into unscreened

agricultural diversions (and see also Figure 10 below).[8] The number of days per year during which the barriers are closed, as well as the numbers of barriers installed, has increased significantly, from less than 150 days per year in the 1990s to well over 200 days per year since 2003, coincident with the recent precipitous delta smelt population decline (Figure 8; Simi and Ruhl 2005). The USFWS (2004) noted that the California Department of Water Resources (CDWR) and the U.S. Bureau of Reclamation (BOR) proposal to replace temporary barriers at the SWP and CVP with permanent barriers could result in additional effects to delta smelt. The proposed permanent barriers operations may include barrier closures during additional periods and may include different operations that could affect delta smelt (USFWS 2004).

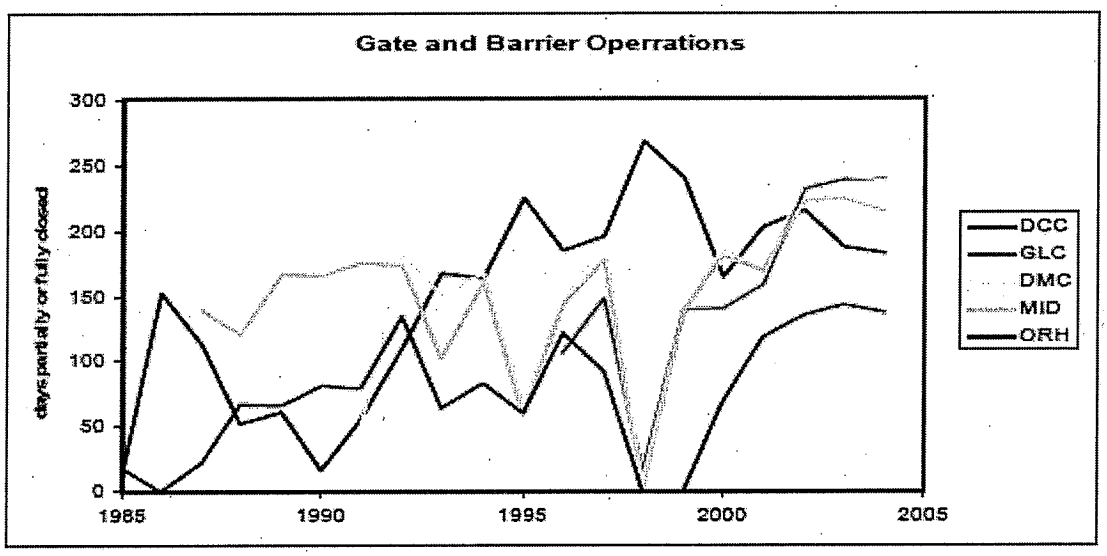


**Figure 8.** The number of days per year during which the four temporary agricultural barriers installed in south Delta channels are closed. Based on particle tracking model results, closure of the barriers corresponds to increased entrainment of small pelagic organisms such as juvenile delta smelt at SWP, CVP and local agricultural diversions. DCC=Delta Cross Channel; GLS=Grant Line Canal barrier; DMC=Old River near the Delta Mendota Canal barrier; MID=Middle River barrier; and ORH=Head of Old River barrier. Source: Simi and Ruhl 2005, Figure 15.

*Population Level Impacts*: Recent analyses have shown that delta smelt population abundance is significantly and inversely related to seasonal export rates (Swanson 2005).[9]

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[8] CDWR uses a computer-based particle tracking model (a module of their Delta Simulation Model, DSM-2) to track and predict the fate of neutrally buoyant particles (which simulate small planktonic and pelagic organisms, or "virtual fish") injected at various location into the Delta under specified inflow, export and barrier operations. Results of particle tracking model studies can be used to evaluate the effects of different water management or barrier operations on fish entrainment rates at SWP, CVP and local agricultural water diversions.

[9] These analyses were conducted by C. Swanson and earlier versions of these results were presented at the CALFED Bay-Delta Program-sponsored Environmental Water Account Review Workshop, Dec. 7-8, 2005, Sacramento, CA. Presentation and supplemental report are available at: http://science.calwater.ca.gov/workshop/ewa.shtml. Analyses presented in this petition have been updated by C. Swanson to incorporate abundance and export data from 2005 and 2006.

Figure 9 and Equations 4 and 5 show that export rates during the winter (December-March) significantly and negatively correlate with the abundances of adult and juvenile delta smelt measured later that year: for both life stages, abundance decreased with increases in exports.[10]

Adult delta smelt (1967-2006):

Log FMWT = 3.11 – 0.37(Dec-Mar exports, MAF) **(Equation 4)**

$n=38$; $p<0.001$; $r^2=0.263$

Juvenile delta smelt (1967-2006):

Log TNS = 1.43 – 0.44 (Dec-Mar exports, MAF) **(Equation 5)**

$n=38$ $p=0.006$, $r^2=0.194$

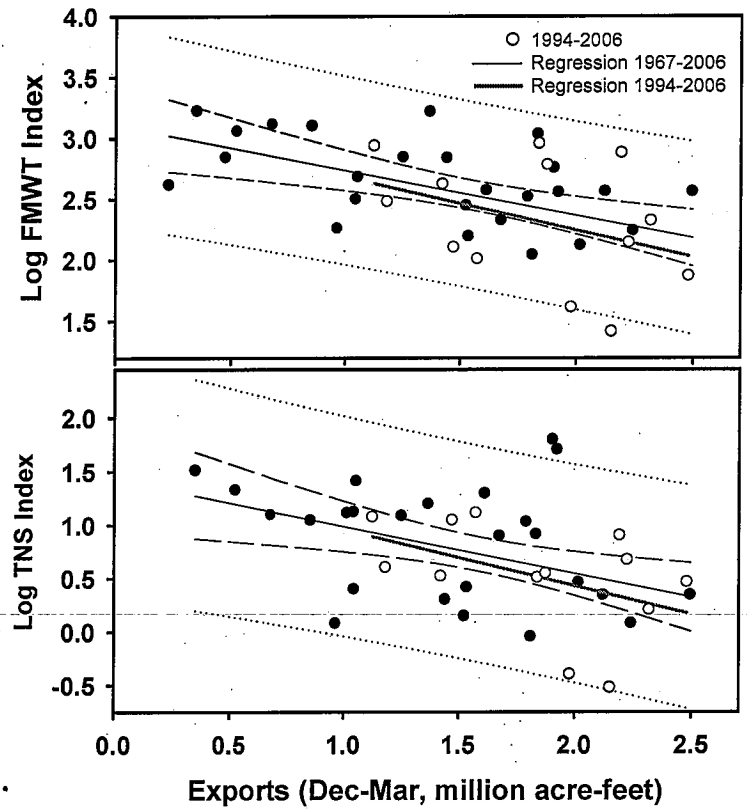


**Figure 9.** The relationship between winter (December-March) export amounts and subsequent abundance of delta smelt. a) sub-adult and adult delta smelt as measured by the FMWT Index (using data from 1967-2006); and b) juvenile delta smelt as measured by the TNS Index (using data from 1969-2006). For each graph, the regression, 95% confidence limits and the prediction limits are shown calculated for the entire datasets. The open symbols and the dark gray regression line highlight the years since the delta smelt was listed under the ESA (1994-2006). Data Sources: California Department of Fish and Game, California Department of Water Resources, Dayflow.

[10] For reference, export of 2.0 MAF during the December-March period corresponds to an average daily combined export rate of the SWP and the CVP of approximately 8,300 cubic feet per second (cfs).

Analyses for the alternative winter periods (November-February, November-March, and December-February) yielded similar and statistically significant results (although p values were somewhat higher and $r^2$ values were somewhat lower).

Large scale ecological changes have occurred in the Delta during the past 30 years, such as the establishment of the invasive clam *Corbula amurensis* and its impacts on the planktonic food web (Kimmerer and Orsi 1996), but they do not strongly affect the results of these types of correlation and regression analyses. For example, the significant relationship between winter exports and the subsequent population abundance of adult delta smelt was apparent in the 20 years prior to the clam's invasion (1967-1986, Equation 6).

Adult delta smelt (1967-1986):

Log FMWT = 3.109 – 0.353(Dec-Mar exports, MAF) **(Equation 6)**
$n=18$; $p=0.013$; $r^2=0.329$

Linear regression using smaller subsets of more recent years (e.g., post-*Corbula* invasion, 1987-2006; post-CESA listing, 1994-2006) were not statistically significant but both the slopes and intercepts of the relationships were very similar to those generated using the entire dataset (see Figure 9). The significant relationship between winter exports and abundance was not "driven" by the low abundances measured during the past three or four years. For example, after excluding the three most recent years for the FMWT abundance indices (2002-2006) from the dataset, the regression was still significant ($p=0.02$) and the slope and intercept were similar to those generated with the entire dataset. Given that the significant relationship between winter exports and adult abundance was detectable by 2002 (and before), this indicates that the low abundances measured during the past three years, a period during which winter exports were at near record high levels, were predictable as early as three years ago.

The abundance of juvenile delta smelt was also significantly affected by spring-summer exports (March-July). The linear regression for this relationship is:

Log TNS = 1.46 – 0.42(Mar-July exports, MAF) **(Equation 7)**
$N=38$; $p=0.044$; $r^2=0.108$

Recent analyses by scientists from University of California, Davis, have provided new insights into the negative effects of high winter and early spring export rates on delta smelt population abundance. Using data and analyses of water temperature, fish distribution, fish size and reproductive condition from CDFG surveys, fish birthdate and age data from otolith analysis, life history models and cohort analyses, Bennett et al. (2006) reported that larger adult delta smelt migrated into the Delta, became reproductively mature and spawned earlier in the season than smaller fish in the population. For most fish species, larger fish are more fecund, produce larger and better quality eggs, and their progeny are more robust and contribute disproportionately to the population (Mager 1996; Moyle and Cech, 2004). However, despite clear evidence of reproductive readiness and spawning by these fish in March and early April, Bennett et

al. (2006) reported that, based on the birthdates of juvenile delta smelt collected later in the year, virtually none of the progeny of these early spawners survived to contribute to the delta smelt population. In fact, only delta smelt hatched shortly before, during, or shortly after the 31-day Vernalis Adaptive Management Program (VAMP) survived to be collected by the CDFG summer TNS.[11] During the VAMP, exports are restricted to very low levels (e.g., 1,500 cfs, or approximately 15-20% of average export rates typical during the months immediately prior to and after the VAMP period) and San Joaquin River inflows to the Delta are increased. Bennett et al. (2006) concluded that the high export rates, low San Joaquin River inflows and associated adverse Delta hydrodynamic conditions during the late winter and early spring of recent years were the major contributor to this massive recruitment failure, lethally entraining both the early spawning adults and, although not reported as incidental take, their larvae and young juvenile progeny. These researchers further concluded that the repeated, near total loss of the most productive and robust component of the delta smelt population was a major contributor to the species' recent precipitous population decline during the 2000s.

Degree and Immediacy of Threat of Present or Threatened Modification or Destruction of Its Habitat

In 1993, when the delta smelt was listed as threatened under both the state and federal Endangered Species Acts, the USFWS identified 21 major federal, state, local or private organization proposals for increased exports (USFWS 1993). By 2006, multiple scientific analyses clearly document that modification and destruction of delta smelt habitat by adverse alteration in freshwater inflows, freshwater outflows, and water exports and diversions has increased significantly since 1993. During the past four years, the magnitudes of these harmful impacts have reached higher levels than have been recorded during the entire 48-year period for which data on delta smelt population abundance exist (1959-2006). Plans for future management of delta smelt habitat and federal and state water management operations, described in detail by USBR (2004a), include plans to increase the magnitude of most of these harmful habitat alterations. The recent 5-year review (USFWS 2004) noted that the potential threat of increased demands on surface water resources in the Central Valley and Delta was growing, citing planned or proposed new water diversion projects such as the Freeport Regional Water Project, increases in pumping capacity at the SWP pumping plant as part of the South Delta Improvement Project, the California Aqueduct/Delta-Mendota Canal inter-tie to allow increased pumping at the CVP pumping plant, Empire Tract on the San Joaquin River; and potential expanded water storage capacity projects at Los Vaqueros, north of the Delta off-stream storage, Shasta Reservoir, in-Delta storage, and south of the Delta surface and groundwater storage projects. Biological evaluations of the impacts of these changes on delta smelt conducted by both USBR (USBR 2004b) and USFWS (2005) conclude that these changes, reduced freshwater outflows, increased Delta exports, and increased lethal entrainment losses, will have negative impacts on the species. In addition, none of the above analyses have considered the predicted consequence of global climate change on delta smelt habitat or on state, federal and local water management operations. Finally, the current severely depressed population abundance of delta smelt,

[11] The Vernalis Adaptive Management Program is usually implemented from April 15 to May 15.

as well as the direct negative impacts of these habitat alterations on key life history stages (i.e., spawning adults) critical to the species continued existence, has reduced the resilience of the species and its capacity to withstand increased harmful habitat degradation.

### 2. Overexploitation

Overexploitation for commercial, recreational, scientific, or educational purposes is not known or thought to be a factor in the decline of the delta smelt population (USFWS 2004). Delta smelt may be harvested as a non-target by-catch in commercial bait fisheries for other baitfish species and some scientific collecting is conducted for the delta smelt, but the USFWS (1993) did not believe these activities were adversely affecting the species.

### 3. Predation, Competition or Disease

According to Moyle et al. (1996, 2004b), there is little evidence that predation, competition or disease has caused the delta smelt population to decline, although diseases and parasites of delta smelt have been little studied. However, introduced species are abundant and increasing in the estuary, including non-native invertebrates and fishes that feed on phytoplankton, zooplankton and/or small fish, and may adversely affect the delta smelt (USFWS 2004). There is some evidence that increased predation pressure on the planktonic food web by introduced species such as the invasive clam *Corbula amurensis* have reduced food availability for delta smelt (and other planktivorous fishes in the estuary; Kimmerer and Orsi 1996; Armor et al. 2005; Thompson and Parchaso 2006) and recent studies have related reduced plankton biomass to reduced delta smelt size (Souza et al. 2005) and liver glycogen levels (Teh 2005), although growth rates are unchanged (Souza et al 2005). However, to date, there is no quantitative evidence that competition for food or space with other aquatic organisms has affected delta smelt abundance.

Introduced striped bass may have caused an increase in predation on all size classes of the delta smelt (USFWS 2004). Efforts to enhance striped bass populations by planting large numbers of juveniles from hatcheries could have had a negative effect on other pelagic fishes in the estuary once the striped bass reached a size where they begin preying upon fish. The enhanced predator populations, without a concomitant enhancement of prey populations such as delta smelt, may have resulted in excessive predation pressure on prey species. Striped bass appear to have switched to piscivorous feeding habits at smaller sizes than they did historically following severe declines in abundance of mysid shrimp (CDWR 2003). The CDFG has completed a Habitat Conservation Plan for their striped bass management program which includes measures designed to help conserve delta smelt.

Introduced planktivores (fish that eat plankton) such as threadfin shad (*Dorosoma pretense*) and inland silverside (*Menidia beryllina*) compete for the zooplankton food of delta smelt, or alter the species composition of the zooplankton community, thereby further decreasing the ability of the delta smelt population to recover. Although the delta

smelt has managed to coexist with these species in the past, it is possible that, at low population levels, interactions with them could prevent recovery. In particular, inland silversides are frequently collected in areas where delta smelt may spawn and they could be major predators on eggs and larvae (Bennett 1995, 2005; CALFED 2001). Estimates of abundance of delta smelt and silversides are negatively correlated, suggesting that inland silversides may be an important predator on larval delta smelt and a competitor for copepod prey. Silversides often occur in dense schools near shorelines and their occurrence may detract from the value of shallow water habitat created to aid delta smelt restoration. Since the early 1980s, there have been increases in other potential larval fish predators such as tagged Chinook salmon smolts released in the delta for survival experiments and non-native centrarchids (CDWR 2003). Introduced species such as the chameleon goby (*Tridentiger trigonocephalus*) and yellowfin goby (*Acanthogobius flavimanus*) may prey on delta smelt eggs and larvae and interfere with recovery of the species.

### 4. Other Natural Occurrences or Human-Related Activities

Global Climate Change

The is gathering evidence that, in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary habitat of delta smelt, the effects of climate change will manifest as:

(1) sea level rise;
(2) changes in timing and amounts freshwater inflow; and
(3) increased frequency and intensity of floods (CCAT 2006).

Sea level raise will shift the interface between inflowing fresh water and saline water from the Bay further upstream in the estuary, a condition known to adversely affect delta smelt habitat quality (Feyrer et al. 2005, 2006; Guerin et al. 2006; and see Historic and Current Distribution and Present and Threatened Modification or Destruction of Its Habitat, Freshwater Inflows and Outflows). Increases in air temperature in the estuary's high elevation watershed is predicted to reduce the volume of the snowpack (i.e., more precipitation will fall as rain rather than snow) and accelerate snowmelt (earlier snowmelt timing in the Sacramento-San Joaquin watershed is already detectable). These changes will result in more frequent and larger flood events, which will likely affect delta smelt habitat by increasing freshwater inflows during the winter and early spring rather than the late springtime freshwater inflows to which the species is adapted. In addition, these changes will have substantial effects on water management operations in the watershed and estuary, including the amounts and timing of upstream storage releases (and resultant Delta inflows), changes in carryover storage amounts (and the ability to provide habitat maintenance flows in sequential dry years), and Delta exports (Anderson 2006; Easton and Ejeta 2006). Recent evaluations of the effects of water management operations on delta smelt (including the most recent Biological Opinion; USFWS 2005) have failed to consider climate change-related effects on either water management operations or on delta smelt habitat.

Reduction in Prey Food Organisms

In recent years, untreated discharges of ship ballast water have introduced non-indigenous aquatic species to the Delta ecosystem (Carlton et al. 1990), several of which adversely affect the delta smelt and its habitat. The USFWS (2004) noted that the discharge of any ballast water into San Francisco Bay is not prohibited and that compliance with a Coast Guard requirement to discharge ballast water before entering U.S. ports is voluntary. Without strictly enforced prohibitions on ballast water discharge in the Bay, additional introductions of non-native species can be expected to continue (Moyle et al. 1996, Moyle 2003). The USFWS (1993, 2004, 2005) discussed the impacts of an introduced clam (*Corbula amurensis*) on the primary food of delta smelt and of non-native copepods that reduce food availability or feeding efficiency of delta smelt. The USFWS (1993, 2004, 2005) also discussed the altered plankton food web in the Delta that may have decreased the growth efficiency of delta smelt larvae.

Toxic Substances

The USFWS (1993, 2004, 2005) discussed the threat to delta smelt of poor water quality due to discharge and transport of agricultural and industrial chemicals from the Central Valley and Delta. Surveys of Delta waters have detected multiple pesticides and herbicides (Kuivila 2000; Houston et al. 2000). The USFWS (1993) noted that irrigation drain water can be harmful to other Delta fish larvae and embryos and to the planktonic food organisms for delta smelt. The SWRCB has designated all of the important water bodies in the delta smelt's range as impaired by one or more contaminants, commonly including pesticides such as diazinon, chlorpyrifos, malathion, chlordane, DDT and dieldrin. There is growing evidence that fish species in the Delta are suffering direct mortality, and physiological and/or developmental impairment from the presence of toxic substances in the water and in the plankton upon which the smelt feed, and that their planktonic food supply may being depleted by periodic, highly concentrated pulses of herbicides and pesticides through the Delta (see USFWS 1996, 1999).

Potential Loss of Genetic Integrity:

Species for which the population level falls below its effective population size are subject to inbreeding and genetic drift. This can result in depressed reproductive vigor and loss of genetic variation, reducing evolutionary fitness of the species and increasing its extinction risk. Using the effective population size criterion developed by Bennett (2003, 2005) and recognized by the USFWS (2004), three consecutive years of a FMWT Index less than 100, the delta smelt is now at risk for loss of its genetic integrity and at greater risk of extinction than when the species was listed under the CESA.

### 5. Inadequacy of Existing Regulatory Mechanisms

The recent delta smelt population decline, substantial increases in environmental and anthropogenic stressors already identified as threats to the species (e.g., Delta water exports), concurrent increases in incidental take, and statistical analyses that reveal

significant relationships between those stressors and the recent and long-term declines in the delta smelt population clearly show that current regulatory mechanisms do not provide adequate protection for the species. In addition, specific protections and management tools identified in the USFWS's 2005 Biological Opinion (USFWS 2005) have proved inadequate and, apparently, unavailable to state and federal fish agency managers attempting to use them to protect the species. Current regulatory mechanisms and their inadequacy to prevent the imminent extinction of the delta smelt are discussed below.

State Threatened Listing

The delta smelt was listed by the State of California as a state threatened species under CESA in December 1993. A CESA listing as threatened theoretically provides some minimal measure of protection to the species because state agencies are required to consult with the CDFG if any project they fund or carry out would adversely affect (or benefit) the delta smelt, and identify and implement protection measures needed to fully mitigate all adverse impacts. As far as we are able to determine, it is unclear if CDFG is enforcing compliance with CESA for the delta smelt: for example, for several important state projects, including recent substantial changes in the SWP (USBR 2004a), no specific mitigation measures have been proposed, no specific incidental take permits have been issued, and no formal or specific consistency determination with federal ESA requirements has been reported. In addition, no state recovery plan exists for the species. This, combined with the collapse of the delta smelt population since state listing, is de facto evidence that the threatened CESA listing is inadequate to protect the species. In contrast, a CESA listing of "endangered" would require evaluation of delta smelt management and the impacts of state-sponsored projects through a sharper lens, supported by the clear evidence provided in this petition that the species is at imminent risk of extinction largely as a result of anthropogenic habitat modification and degradation.

State Listing of Other Species Within the Range of the Delta Smelt

Two other fish species that periodically co-occur with delta smelt are listed under the CESA: winter-run Chinook salmon (*Oncorhynchus tshawytscha*) and spring-run Chinook salmon (*O. tshawytscha*). With the exception of periodic water export reductions using either the CVPIA or EWA (see sections below), most of the habitat restoration and protective actions for Chinook salmon have been implemented outside the geographic range of the delta smelt and therefore provide neither benefit to nor protection of the species.

Federal Threatened Listing

As demonstrated by the declining population trend since delta smelt was federally listed as threatened in 1993, a trend that has culminated in the recent catastrophic decline to record low levels, as well as the extinction risk analysis discussed above, the protections currently afforded by the federal threatened listing, and implementation and enforcement

of those protections, are clearly inadequate to protect delta smelt. During the past 13 years, many of the threats identified by the USFWS in the original listing documents have not been eliminated or mitigated and have instead, in a number of instances, increased. Proposals to further increase the level of several key threats to the species (e.g., Delta water exports) have been approved by USFWS with "no jeopardy" biological opinions (USFWS 2005, and see below). It is also apparent that the qualitative and quantitative recovery criteria specified for the species (Moyle et al. 1996) are insufficiently protective and inadequate to ensure continued existence of the species, particularly in the context of escalating threats to the species and inadequate regulatory protections.

1995 SWRCB Water Quality Control Plan

Overall water management operations in the Sacramento-San Joaquin Delta are regulated by the California State Water Resources Control Board, according to their 1995 Water Quality Control Plan (WQCP) (SWRCB 1995). One subset of the WQCP's water quality objectives is specifically for the protection of fish and wildlife beneficial uses. Among other protections, these regulations limit Delta water exports in relation to Delta inflow (the Export/Inflow, or E/I, ratio), allowing up to 35% of total Delta inflow to be exported during the spring (February-June) and up to 65% to be exported during the rest of the year (July-January).[12] However, depending on inflow conditions, this can allow exports to be as high as (or higher than) 600,000 thousand acre-feet (AF) per month (or >10,000 cubic feet per second [cfs]), levels that, according the analyses above, reliably correspond to low population levels for delta smelt.[13] For example, December-March exports have exceeded 2 million AF in nine of 40 years since 1967 (1983, 1988, 1989, 1990, 2000, 2002, 2003, 2004, and 2005). For those years, the delta smelt Recovery Index averaged 74, the level identified by the 2005 Biological Opinion to correspond to a "high level of concern" for the species and which is supposed to trigger additional protective actions (see Table 1). The Recovery Index fell below 74 in five of the nine years. By comparison, the Recovery Index exceeded 74 in 82% of years in which December-March exports were less than 1.5 million AF. Given that the Recovery Index has a threshold value of 239 that must be achieved in two of five sequential years for recovery of the species, this suggests that high export levels currently allowed by the WQCP and which have been implemented with increasing frequency during recent years (and which are predicted to occur even more frequently in the future; see 2005 Biological Opinion below) are incompatible with the recovery of delta smelt.

Export levels allowed under the WQCP also do not protect key areas of delta smelt critical habitat. Recent analyses using CDWR's Delta Simulation Model (DSM-2) and its Particle Tracking Module show that most particles (which are thought to reasonably

[12] In the WQCP exports are defined as the combined exports of the federal Central Valley Project and the State Water Project. For a 31-day period during the spring (usually April 15-May 15), lower exports are required by the San Joaquin River Agreement as part of the Vernalis Adaptive Management Plan.

[13] Average Delta exports rates for the December-March period exceeded 10,000 cfs in 1990 and 2004. Since 2000, average December-March exports exceeded 9,000 cfs in four of the last seven years (2000, 2002, 2003, and 2004).

simulate larval and small juvenile delta smelt but be somewhat less accurate simulations for adult delta smelt) released into the southern and central Delta were lost within two weeks to entrainment at either the government water project diversions or the many unscreened agricultural diversions located in this area of the Delta (Figure 10). For particles released at Bacon Island in the southern Delta, virtually all the particles were entrained at E/I ratios >20%, a level well within the currently allowed operations. For particles released in the central Delta (Twitchell Island), the percentage entrained increased linearly with the E/I ratio. This shows that E/I ratios allowed by the current WQCP may be effectively eliminating large areas of the southern and central Delta as usable habitat for delta smelt spawning and early rearing (see Historic and Current Distribution above).

Although the E/I regulations established in 1995 with the WQCP prevented extreme water management operations such as those that occurred in the late 1980s and early 1990s, since that time (and since the delta smelt was listed under the CESA), seasonal E/I ratios have increased by more than 90% for the winter period (from 14% in 1995-1999 to 27% in 2002-2006) and by 50% in the spring (from 16% to 24%) (Figure 11).

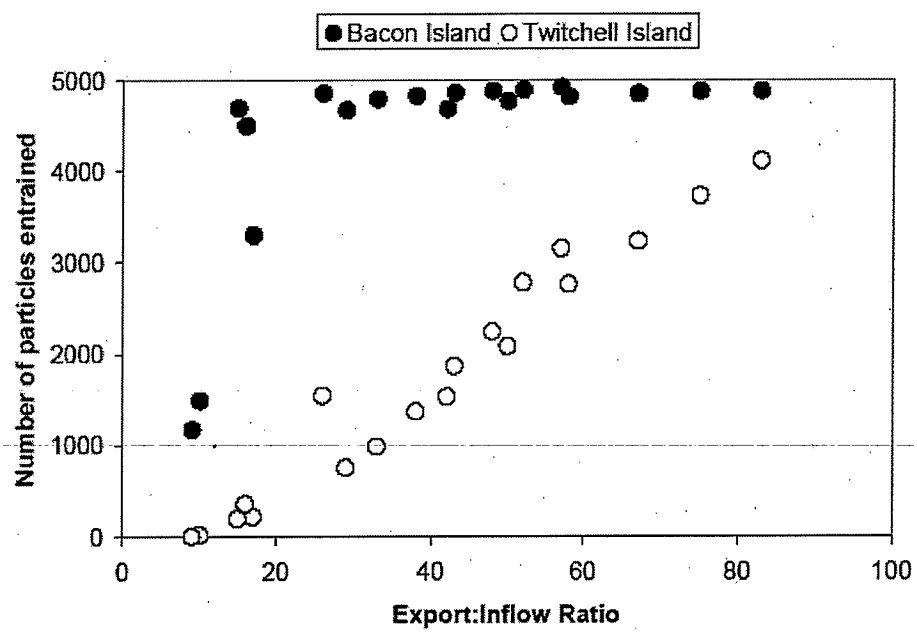


**Figure 10.** The relationship of the E/I ratio to the number of particles entrained (out of 5,000 particles released) over a series of Particle Tracking Model runs. Source: Herbold et al. 2005, Figure 8.

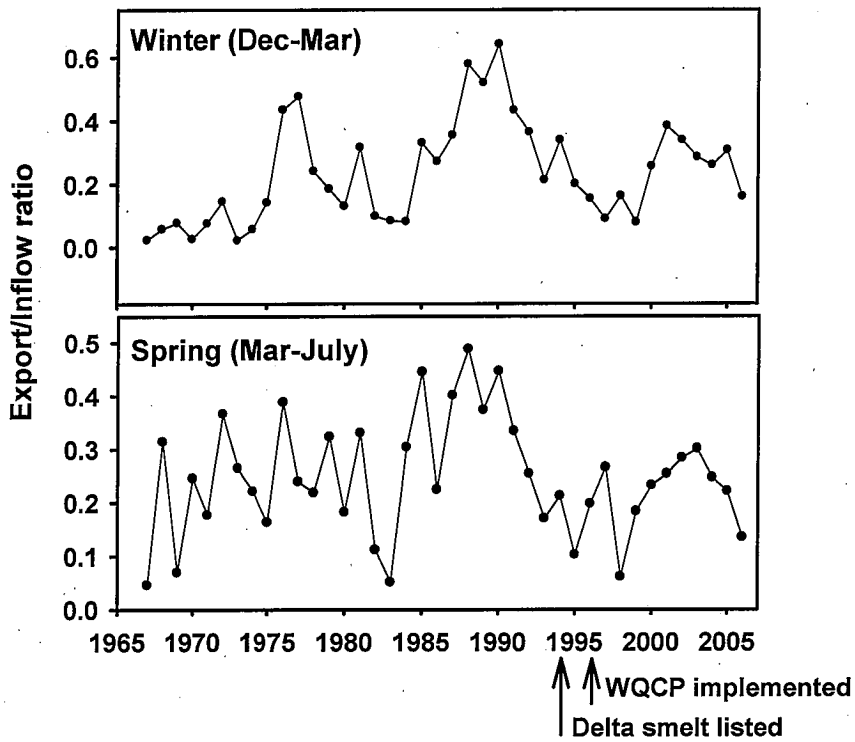


**Figure 11.** Trends in the Export/Inflow ratio (E/I) during the winter (December-March, upper panel) and spring (March-July, lower panel). The Water Quality Control Plan allows a maximum E/I of 65% during the fall and winter (July-January) and 35% during the spring (February-June). Data source: California Department of Water Resources, Dayflow.

In 2004 and 2005, the SWRCB began review of the 1995 WQCP, holding a series of informational workshops to evaluate the adequacy of the regulatory objectives designed to protect fish and wildlife beneficial uses in the estuary. Petitioners (The Bay Institute) submitted extensive comments on the status of the estuarine ecosystem and delta smelt, information and interpretation of the relevant science available at the time, and made a number of recommendations for changes in the regulatory objectives that were specifically designed to improve protection of the estuarine habitat and delta smelt (and other species).[14] However, despite clear evidence of the deteriorating condition of the species and its estuarine habitat (including well publicized reports of the dramatic pelagic organism decline in early 2005), the 2006 WQCP recently released by the SWRCB includes no changes in water quality, freshwater inflow and outflow, or export operation objectives known to affect delta smelt and which, based on information available then, were known to be inadequate to protect the delta smelt.[15]

[14] The Bay Institute's submissions to the SWRCB for the review of the 1995 WQCP are available at: http://www.waterrights.ca.gov/baydelta/exhibits_list.htm#bi

[15] The 2006 WQCP is available at: http://www.waterrights.ca.gov/baydelta/2006controlplan.html

2005 USFWS Biological Opinion

A 2005 Formal and Early Endangered Species Consultation on the Coordinated Operations of the CVP and SWP and an Operations Criteria and Plan (USFWS 2005) was intended to evaluate the impacts of the proposed future federal and state water management operations on delta smelt.[16] The Consultation resulted in a February 2005 Biological Opinion by the U.S. Department of the Interior concluding that federal and state water exports from the Delta could increase without jeopardizing listed delta smelt. The Consultation identified specific fish protection management tools, such as the CALFED Environmental Water Account (EWA), that will be used to mitigate the impacts of those actions on delta smelt using real-time management.[17] This regulatory mechanism provides inadequate protection for delta smelt for numerous reasons, including: 1) the effects of the proposed action are not adequately or correctly evaluated and adverse impacts are therefore seriously underestimated; and 2) the specified protective tools and management actions are known to be inadequate, not guaranteed to be available, and are not required to be implemented when requested by state and federal fish agencies for protection of the species.

The only evaluation of the impacts to delta smelt from the predicted increases in Delta water exports included in the 2005 Biological Opinion was based on estimates of increased incidental take. Increased take was calculated based on linear increases with increases in exports, an estimate that recent analyses by Herbold et al. (2005) suggest is seriously flawed (this analysis showed disproportionate increases in incidental take with recent increases in exports; see Figure 7). In addition, incidental take is known to be a poor predictor of either actual direct impacts or population level effects. The Biological Opinion lacks even basic statistical analyses of the effects of Delta exports on delta smelt population abundance. Given that statistically significant relationships between these important variables are detectable using the data that were available to the USFWS (and the BOR, which prepared the Biological Assessment) at the time the Biological Opinion was prepared (see Modification of Habitat, Population Level Effects above and Figure 9), this represents a failure to use best available science, a legal requirement for this type of regulatory mechanism. Further, the results of these types of analyses (as well as even a cursory review of recent abundance and export data) clearly show that export rates proposed in the described project are incompatible with stabilizing the population at levels above those identified in the Biological Opinion that trigger a "high level of concern", much less recovering the species.[18]

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[16] In July 2006, the USBR requested reintitiation of consultation for the effects of coordinated water management operations on delta smelt. They proposed, and the USFWS agreed, to leave the 2005 Biological Opinion in effect during the estimated 20-month period while the Biological Opinion was completed.

[17] The Environmental Water Account (EWA) is a supply of water managed by the state and federal fish agencies to facilitate periodic reductions in SWP and/or CVP exports at times when ESA-listed fish species are near the facilities and vulnerable to entrainment. EWA water is used to compensate the SWP and CVP for reductions in deliveries that might result from the export curtailment.

[18] In the action evaluated by the Biological Opinion, average December-March exports are predicted to be >9,000-10,000 cfs in nearly all years.

The 2005 Biological Opinion uses a "Delta Smelt Risk Assessment Matrix" (DSRAM) to identify conditions under which delta smelt are at risk from water project operations (primarily entrainment loss at the Delta export facilities) and identifies "export reduction at one or both facilities" as one its protective "tools for change".

To implement protective actions recommended by the multi-agency Delta Smelt Working Group (DSWG, also specified and described in the Biological Opinion), the Biological Opinion relies on the CALFED Bay-Delta Program's EWA to facilitate export reductions and to provide water resources to compensate for reduced deliveries that might result from the fish protection action. However, to date the EWA has been authorized and funded only on an annual basis and the likelihood of its continued existence beyond 2007 is unknown. In addition, the EWA's utility for fish protection and the ability of the state and federal fish agencies to use it to implement specific protective actions as recommended by the multi-agency DSWG appears highly uncertain. In 2005, two out of three recommendations for protective actions made by the DSWG based on the risk criteria in the DSRAM were not implemented as recommended by the state and federal water project agencies (despite adequate water assets in the EWA) (Poage 2005). For example, in January of 2005 at least three of the risk criteria were exceeded and the monthly incidental take limit was nearly exceeded before an export reduction was implemented, an inexplicable delay given the high level of concern based on the then record low FMWT Index. When the reduction was finally implemented, neither the recommended export level nor duration was agreed to by the Water Operations Management Team (WOMT), who opted instead for a smaller and shorter export curtailment. Later in the spring, the DSWG-recommended export level for the 31-day Vernalis Adaptive Management Plan (VAMP) was rejected by the WOMT, who allowed for exports 50% greater than the recommended level. Three weeks later the SWP unilaterally discontinued its export curtailment before the VAMP period was concluded. The following summer, the abundance of juvenile delta smelt reached a record low and, when adult fish were surveyed in the fall, their numbers were also at new record lows. More recently, the DSWG has explicitly declined to make recommendations for Delta exports actions that their analyses have determined would provide the benefit for delta smelt, citing concerns about the inadequate supplies of EWA water assets. In December 2006, the DSWG rejected a proposed protective action to eliminate negative flows on Old and Middle rivers in the south Delta during the delta smelt's winter spawning season that "would be better for delta smelt" because it "could consume all available environmental water, leaving no assets for spring actions for larvae or juveniles" (DSWG 2006).

Central Valley Project Improvement Act

The Central Valley Project Improvement Act (CVPIA), implemented in 1992, was intended to improve habitat conditions and reduce adverse direct and indirect impacts of CVP operations on fish and wildlife resources, with an emphasis on anadromous fish species. With the exception of small, short-duration water export reductions at the CVP export facility (usually timed to protect migrating juvenile salmonids), most of the habitat restoration and protective actions specified by the program (e.g., gravel restoration, stream flow enhancement, installation of fish screens and ladders) have been

implemented outside the geographic range of the delta smelt and therefore provide neither benefit nor protection to the species.

CALFED Bay-Delta Program

The CALFED Bay-Delta Program (CALFED) is a joint state-federal effort to restore the ecological health of the Bay-Delta system, protect and recover fish and wildlife species, increase water supply and reliability, and improve levee integrity and water quality. The delta smelt is identified by CALFED as a priority species. Within delta smelt habitat, CALFED has implemented three categories of restoration and protective actions intended, at least in part, to protect and recover the species: restoration of shallow water habitat; reduction of entrainment losses using the EWA; and installation of fish screens.

*Habitat restoration:* Restoration of shallow water habitat within the delta smelt's range has proceeded slowly and there is little evidence that the species derives benefit from the few small projects that have been completed (Brown 2003). There is no real evidence that access to shallow water habitat represents a limiting factor for the species (Bennett 2005).

*Export curtailments and the EWA:* The most recent Biological Opinion for delta smelt (USFWS 2005) relies heavily on use of the EWA, a tool to facilitate periodic export curtailments and reduce entrainment losses that was developed by CALFED as a four-year experiment. The USFWS (2004) cited the EWA and the 31-day-long spring VAMP export curtailment that is largely implemented using EWA water as examples of water management tools that are addressing specific needs of delta smelt. During the past six years, however, state and federal agencies have reduced by 300,000 to 400,000 acre-feet per year the amount of water required by the CALFED Record of Decision (ROD) to protect the Delta and fisheries under the EWA (Environmental Defense 2005). Moreover, the USFWS (2004) also noted that the delta smelt population declined during the three years of EWA actions that were analyzed in their 5-year review. In 2006, after six years of EWA implementation, Delta exports during seasons when delta smelt are vulnerable to direct and indirect impacts have continued to increase and the abundance of juvenile and adult delta smelt population has dropped to critically low levels.

The EWA is now in its seventh year of implementation. The program has been subject to five formal reviews by an independent science panel (2001, 2002, 2003, 2004, and 2006) and a sixth informal review in 2005. Despite these exhaustive reviews, the state and federal fish agencies managing the EWA have presented no evidence to indicate that the EWA is an effective tool for mitigating the adverse impacts of Delta export operations or even for reducing entrainment loss of fish at the SWP and CVP facilities. Similarly, there is no evidence that the EWA provides population level benefits to any of the ESA-listed species that are the focus of its actions. The current EWA is clearly not providing adequate protection to delta smelt. The USFWS (2004) reported that the EWA is currently being "resized" to account for proposed increases in water exports at the state and federal export facilities, however, the proposed future EWA actually has less water

than the original version described in the CALFED ROD. Therefore, a "resized" EWA will not likely provide adequate protection for delta smelt either.

*Installation of fish screens:* The USFWS 5-year review (2004) cited installation of two fish screens on water diversions within the range of delta smelt under the auspices of the CALFED Bay-Delta Program as representing "progress towards eliminating entrainment of delta smelt in unscreened diversions," but acknowledged that over 1,800 unscreened or inadequately screened diversions still operate in delta smelt critical habitat. Plans to renovate and upgrade the fish louvers and screens at the SWP and CVP fish facilities, which entrain the vast majority of larval, juvenile and adult delta smelt, have been indefinitely postponed (SDFFF 2005)

Federal Listing of Other Species Within the Range of the Delta Smelt

Four other fish species that periodically co-occur with delta smelt are listed under the federal ESA: winter-run Chinook salmon (*Oncorhynchus tshawytscha*), spring-run Chinook salmon (*O. tshawytscha*), Central Valley steelhead (*O. mykiss*), and most recently, the southern population of green sturgeon (*Acipenser medirostris*). With the exception of periodic water export reductions using either the CVPIA or EWA (see above sections), most of the habitat restoration and protective actions for these species have been implemented outside the geographic range of the delta smelt and therefore provide neither benefit to nor protection of the species.

CEQA and NEPA

The environmental review process under the California Environmental Quality Act, California Public Resources Code §21000 et. seq. (CEQA) should theoretically provide some protection to delta smelt. CEQA declares that it is the policy of the state to "(p)revent the elimination of fish or wildlife species due to man's activities, ensure that fish and wildlife populations do not drop below self-perpetuating levels, and preserve for future generations representations of all plant and animal communities." (California Public Resources Code, section 21001(c)). The CEQA process is triggered when discretionary activities of state agencies may have a significant effect on the environment. When the CEQA process is triggered, it requires full disclosure of the potential environmental impacts of proposed projects. The operative document for major projects is usually the Environmental Impact Report.

Theoretically, besides ensuring environmental protection through procedural and informational means, CEQA also has substantive mandates for environmental protection. The most important of these is the provision requiring public agencies to deny approval of a project with significant adverse effects when feasible alternatives or feasible mitigation measures can substantially lessen such effects. *Citizens for Quality Growth v. City of Mt. Shasta,* 198 Cal.App.3d 433, 440_441 (1988); CA. Pub. Res. Code § 21002; 14 Cal. Code Regs. §§ 15002(a)(3), 15021(a)(2) and (c), 15041(c), 15364, 15370. In practice, however, this substantive mandate has not been implemented, especially with regard to protection of the delta smelt. In practice, alternatives that would protect the

delta smelt and other wildlife are almost universally dismissed as "infeasible." Mitigation, when required, is often ineffective or only marginally effective.

The National Environmental Policy Act ("NEPA") also requires that federal agencies fully and publicly disclose the potential environmental impacts of proposed projects, but NEPA lacks even the minimal substantive provisions of CEQA.

## III. RECOMMENDED MANAGEMENT AND RECOVERY ACTIONS

Since 1993, when the delta smelt was first listed under the state and federal ESAs, scientific understanding of the species and its estuarine habitat has increased substantially. During the same period, overall ecological conditions in the estuary have further degraded and the status of species has deteriorated to point where it is at risk of imminent extinction. While there are a number of ongoing monitoring, research and, to a lesser extent, habitat protection efforts underway, additional activities are necessary to protect and improve the status of delta smelt. Based on the results and interpretations of the best available science (much of it described in this petition), and review of current management of the species and its habitat, we recommend the following management and recovery activities.

Activities That Would Protect the Existing Population of Delta Smelt

1. Reduce Delta water exports and/or increase freshwater inflows from the San Joaquin River for a minimum of 30 to 60 consecutive days in the late winter/early spring (i.e., prior to implementation of the VAMP) to improve in-Delta hydrodynamic conditions and improve survival of early arriving adult delta smelt and their larvae. The management action should be timed to coincide with the early spawning period of delta smelt, as determined based on CDFG survey data and Delta water temperatures.
2. Increase freshwater flows through the Delta during the spring (February-June) beyond minimum levels currently required by the SWRCB's 1995 WQCP to improve estuarine habitat.
3. Increase freshwater outflows during the fall (October-December) to maintain low salinity habitat (as defined by X2) no more than 80 km from the Golden Gate to improve estuarine habitat, restrict the invasive clam *Corbula amurensis*, and reduce proximity of delta smelt to the zone of influence of the exports pumps.
4. Install fish screens on unscreened water diversions in areas of the Delta and Suisun Marsh that are determined to be in operation during periods when juvenile and/or adult delta smelt may be present.
5. Install fish screens on the cooling water intakes for commercial power plants and/or prohibit water intake operations during periods when delta smelt may be present (as based on life history and CDFG survey data).
6. Replace and/or renovate fish and debris screens at the SWP and CVP fish protective facilities and revise operational protocols (e.g., Clifton Court Forebay gate operations, day vs. night pumping regimes, fish collection, handling and transport methods) to reduce entrainment and mortality of delta smelt.
7. Restore and/or accelerate ongoing restoration of tidal marsh habitats in Suisun Marsh, which function to produce phyto- and zooplanktonic food organisms for delta smelt in the marsh and the upper estuary.

Monitoring Programs and Studies

1. Continue ongoing CDFG survey programs, including the FMWT, summer TNS, 20 mm Survey, Spring Kodiak Trawl Survey, Bay Study, and fish salvage monitoring at the SWP and CVP fish protective facilities.
2. Implement monitoring for larval and small juvenile (<20 mm in length) delta smelt entrained into the SWP and CVP export facilities.
3. Complete CDFG-sponsored Collection, Handling, Transport and Release (CHTR) studies and apply results to develop methods for improving survival of delta smelt salvaged at the SWP and CVP facilities.
4. Continue and expand multi-agency research studies of the pelagic organism decline.
5. Develop and facilitate implementation of large scale ecological experiments in the Delta that are designed to test alternative management strategies on the Delta ecosystem (e.g., effects of freshwater inflows or salinity on survival, distribution and abundance of native or invasive species), in-Delta hydrodynamics, and fish entrainment rates.
6. Facilitate the translation and transfer of scientific results to management actions, either as adaptive management experiments, species-specific protection actions, or regulatory objectives.

Needed Amendments to Existing Management and Land-use Plans

1. Revise the state's Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (SWRCB 2006) to incorporate additional protections for estuarine habitat and the delta smelt.
2. Eliminate current waivers for regulation of agricultural discharges from farmlands in the Sacramento and San Joaquin valleys recently approved by the Central Valley Regional Water Quality Control Board (CVRWQCB). Require reductions in the types and amounts of toxic compounds that can be discharged into rivers and streams tributary to the Delta and upper estuary.

Benefits to Other Species

Implementation of additional protection, management and restoration activities for delta smelt (including the recommendations listed above) will, by improving estuarine habitat and reducing adverse in-Delta hydrodynamic conditions, provide benefits to many other sensitive species that reside in or use the estuary for some portion of their life cycle, including longfin smelt (*Spirinchus thaleichthys*), splittail (*Pogonichthys macrolepidotus*), winter-run Chinook salmon (*Oncorhynchus tshawytscha*; CESA-endangered, ESA-endangered), spring-run Chinook salmon (*O. tshawytscha*; CESA-threatened, ESA-threatened), steelhead trout (*O. mykiss*; ESA-threatened), green sturgeon (*Acipenser medirostris*; ESA-threatened), white sturgeon (*A. transmontanus*), and striped bass (*Morone saxatilis*). In addition, improved estuarine habitat will likely provide less favorable conditions for several harmful non-native species, including invasive plants

(e.g., *Egeria densa*), invertebrates (*Corbula amurensis*), and fishes (warm water basses, family Centrarchidae).

Agency Participation in Delta Smelt Protection

Protection of delta smelt will require cooperation and participation of state federal and local agencies and organizations, including USFWS, USBR, U. S. Army Corps of Engineers (which participates in repair and maintenance of Delta levees, and regulates maximum export rates at the SWP), CDFG, CDWR, SWRCB, CVRWQCB, Contra Costa Water District and other water districts which receive Delta water deliveries, and local irrigation districts.

Recovery Criteria for Delta Smelt

In 1996, USFWS sponsored development of a recovery plan for native Delta fishes, which included a section for delta smelt (USFWS 1996). The recovery plan included numeric criteria for delta smelt population abundance (based on the Recovery Index, see Table 1) and distribution of the fish within their habitat. Recovery was partially defined as the achievement of specific levels of the two numeric criteria during a period of five consecutive years in which specific hydrological conditions were required to have occurred. Other criteria for recovery included mitigation and/or elimination of threats to the species. In 2003, the numeric abundance, distribution and hydrological criteria were met within the specified five-year window, even though delta population abundance had already declined markedly. This demonstrated that these recovery criteria, developed more than a decade ago without the benefit of the substantial new understanding gained in recent years, were not reliable indicators to characterize a stable and sustainable delta smelt population. Development of new recovery criteria should build on this lesson and also incorporate the new information available on delta smelt extinction risk, population dynamics, subtle variations in life history patterns, habitat requirements and preferences, and emerging threats to the species (e.g., climate change).

## IV. CONCLUSION

The USFWS (2004) recently concluded that the threats to delta smelt described in the original listing remain, including the destruction, modification, or curtailment of the delta smelt's habitat or range resulting from extreme freshwater outflow conditions (reduced outflow or high outflow), operations of the State and Federal water projects, and other water diversions. CDFG (2003) and Moyle (2002, 2003) concluded that these threats could result in the extinction of the delta smelt. In addition, any one of the many stochastic factors that affect delta smelt, such as predation, invasive species, change in food organisms, toxic substances, disease, competition, and entrainment losses to water diversions can cause their numbers to move towards extinction (Moyle 2002, 2003).

In 2003, the USFWS (2004) concluded that new information concerning the delta smelt's population size and extinction probability indicated that the population was at risk of falling below an effective population size and therefore in danger of becoming extinct. Since the USFWS status review, the delta smelt population has indeed fallen below an effective population size and is therefore in danger of becoming extinct.

Recent population viability and extinction risk analyses indicate that, conservatively, the delta smelt could go extinct within the next 20 years and new analyses have demonstrated a statistically significant relationship between delta smelt population abundance and both freshwater outflow levels and Delta export rates. Despite the availability of this new information regarding the likelihood of extinction of the species and the delta smelt's decline to record low levels for three consecutive years (2004, 2005 and 2006), neither the Commission, USFWS nor other agencies charged with protecting the delta smelt and its Delta habitat have taken major actions to reverse the decline. Indeed, state and federal agencies continue to proceed with plans to that would exacerbate current conditions for the delta smelt, including increasing export levels at the Delta pumping facilities and developing new water diversion and storage projects which will reduce Delta inflow and outflow and further degrade delta smelt habitat.

The warning signs could not be clearer: the delta smelt is at high risk of extinction. We urgently petition the California Fish and Game Commission to list the delta smelt as endangered under the CESA, and to immediately implement measures to curtail threats to the species and improve environmental conditions in its Delta habitat.

## V. SIGNATURE PAGE

Submitted this 7th day of February, 2007

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## VII. BIBLIOGRAPHY OF LITERATURE CITED


Anderson, J. D. 2006. Preliminary climate change impacts assessment for the Sacramento-San Joaquin Delta. CALFED Science Conference, October 23-25, 2006, Sacramento, CA. Abstract available at: http://sciconf.abag.ca.gov/conferences/abstract_view_01a.php

Armor, C., R. Baxter, B. Bennett, R. Breuer, M. Chotkowski, P. Coulston, D. Denton, B. Herbold, K. Larsen, M. Nobriga, K. Rose, T. Sommer, and M. Stacey. 2005. Interagency Ecological Program synthesis of 2005 work to evaluate the Pelagic Organism Decline (POD) in the upper San Francisco Estuary. Available at: http://www.science.calwater.ca.gov/workshop/workshop_pod.shtml

Armor, C. S. 2006. POD 2007 Study Plan: "Are we there yet?". CALFED Science Conference, October 23-25, 2006, Sacramento, CA. Abstract available at: http://sciconf.abag.ca.gov/conferences/abstract_view_01a.php.

Bennett, W. A. 1995. Potential effects of exotic inland silversides on delta smelt. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter. 8(1):4-6.

Bennett, W. A. 2003. The Population Ecology of Delta Smelt in the San Francisco Estuary. 44 pp.

Bennett, W. A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California. San Francisco Estuary and Watershed Science 3(2):1-71.

Bennett, W. A., J. A. Hobbs, and S. J. Teh. 2006. Delta smelt growth and survival during the recent pelagic organism decline: what causes them summertime blues? CALFED Science Conference, October 23-25, 2006, Sacramento, CA. Abstract available at: http://sciconf.abag.ca.gov/conferences/abstract_view_01a.php

Brown, L. R. 2003. Will tidal wetland restoration enhance populations of native fishes? San Francisco Estuary and Watershed Science. Vol. 1, Article 2. 42 pp.

Bowen, M. D., B. B. Baskerville-Bridges, K. W. Frizell, L. Hess, C. A. Carp, S. M. Siegfried, and S. L. Wynn, 2004. Empirical and experimental analyses of secondary louver efficiency at the Tracy Fish Collection Facility, March 1996 to November 1997, Tracy Fish Facility Studies, Volume 11, U. S. Bureau of Reclamation, Mid Pacific Region, Denver Technical Service Center, 33 pp + Figures.

CALFED Bay-Delta Program. 2001. Delta Smelt and CALFED's Environmental Water Account: Summary of a Workshop held September 7, 2001 at the University of California, Davis. Sacramento, California.

California Climate Action Team (CCAT) 2006. Climate Action Team Report to Governor Schwarzenegger and the California Legislature. California Environmental Protection Agency, March 2006. 110 pp. Available at: http://www.caclimatechange.net/index.cfm?objectID=F60D11B9-BDBA-8C61-AF30B1106C75786A

California Department of Fish and Game (CDFG). 2003. Comment Letter on the Five Year Status Review of the Delta Smelt. 6 pp.

California Department of Water Resources (CDWR). 2003. Comment Letter on the Five Year Status Review of the Delta Smelt. 20 pp.

Carlton, J. T., J. K. Thompson, L. E. Schemel, and F. H. Nichols. 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis*. I. Introduction and dispersal. Mar. Ecol. Prog. Ser. 66: 81-94.

Delta Smelt Working Group (DSWG). 2006. Delta smelt working group meeting notes, December 11, 2006. Available at: http://www.fws.gov/sacramento/es/documents/ds_working_group/DSWG_Minutes_11-Dec-06.pdf

Easton, D. J. and M. Z. Ejeta. 2006. Preliminary climate change impacts assessment for SWP and CVP operations. CALFED Science Conference, October 23-25, 2006, Sacramento, CA. Abstract available at: http://sciconf.abag.ca.gov/conferences/abstract_view_01a.php

Environmental Defense. 2005. Finding the water. New water supply opportunities to revive the San Francisco Bay-Delta ecosystem. Environmental Defense, Oakland, CA. 22 pp.

Erkkila, L. F., J. F. Moffett, O. B. Cope, B. R. Smith, and R. S. Nelson. 1950. Sacramento-San Joaquin Delta fishery resources: effects of Tracy pumping plant and delta cross channel. U.S. Fish and Wildl. Serv. Spec. Sci. Rep. Fisheries 56. 109 pp.

Feyrer, F. M. Nobriga, and T. Sommer. 2005. Progress report on physical habitat trend analyses for Fall Midwater trawl. In: IEP synthesis of 2005 work to evaluate the pelagic organism decline (POD) in the upper San Francisco Estuary. Available at: http://www.science.calwater.ca.gov/workshop/workshop_pod.shtml

Feyrer, F. M. Nobriga, and T. Sommer. 2006. Multi-decadal habitat trends: patterns and mechanisms for three fishes in the San Francisco Estuary. CALFED Science Conference, October 23-25, 2006, Sacramento, CA. Abstract available at: http://sciconf.abag.ca.gov/conferences/abstract_view_01a.php

Fleming, K. and M. Nobriga. 2004. Status of delta smelt: multi-decadal trends in abundance, distribution, and water management. CALFED Bay-Delta Program Science Conference. October 4-6, 2004. Sacramento, California.

Guerin, M., G. Gartrell, and R. Denton. 2006. Linkages between fall salinity, Delta outflow, and delta smelt population decline. CALFED Science Conference, October 23-25, 2006, Sacramento, CA. Abstract available at: http://sciconf.abag.ca.gov/conferences/abstract_view_01a.php

Herbold, B., C. Armor, R. Baxter, M. Chotkowski, P. Coulston, M. Nobriga, and T. Sommer. 2005. Historical patterns in salvage data. In: IEP synthesis of 2005 work to evaluate the pelagic organism decline (POD) in the upper San Francisco Estuary. Available at: http://www.science.calwater.ca.gov/workshop/workshop_pod.shtml

Herbold, B. C. S. Armor, R. Baxter, M. W. Chotkowski, M. Gringas, A. B. Mueller-Solger, M. L. Nobriga, and T. R. Sommer. 2006. POD conceptual synthesis. CALFED Science Conference, October 23-25, 2006, Sacramento, CA. Abstract available at: http://sciconf.abag.ca.gov/conferences/abstract_view_01a.php

Herren, J. R. and S. S. Kawasaki. 2001. Inventory of water diversions in four geographic areas in California Central Valley. California Fish and Game Fish Bulletin 179:343-355.

Houston, J. R, L. A. Allen, and K. M. Kuivila. 2000. Seasonal patterns and factors controlling the occurrence of dissolved pesticides in the Sacramento-San Joaquin Delta. CALFED Bay-Delta Program Science Conference, Oct. 3-5, 2000, Sacramento, CA. Abstract (#169), summary, and notes available at www.iep.water.ca.gov/calfed/sciconf/2000/publications/.

Kimmerer, W. J. and J. J. Orsi. 1996. Changes in the zooplankton of the San Francisco Bay Estuary since introduction of the clam *Potamocorbula amurensis*. Pages 403-424. *In* J. T. Hollibaugh, ed. San Francisco Bay: the ecosystem. Pacific Division of the American Association for the Advancement of Science. San Francisco, California, USA.

Kuivila, K. M. 2000. Pesticides in the Sacramento-San Joaquin Delta: State of Our Knowledge. CALFED Bay-Delta Program Science Conference, Oct. 3-5, 2000, Sacramento, CA. Abstract (#66), summary, and notes available at www.iep.water.ca.gov/calfed/sciconf/2000/publications/.

Mager, R. 1996. Gametogenesis, reproduction, and artificial propagation of delta smelt, *Hypomesus transpacificus*. Ph.D. Dissertation. University of California, Davis.

Matica, Z. and T. Sommer. 2005. Aquatic impacts of the Pittsburg and Contra Costa power plant. In: IEP synthesis of 2005 work to evaluate the pelagic organism decline (POD) in the upper San Francisco Estuary. Available at: http://www.science.calwater.ca.gov/workshop/workshop_pod.shtml

Miller, L. W. 2000. The tow-net survey for delta smelt revisited. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter. 13(1):37-44.

Moon, G. E, K. M. Kuivila, and J. L. Orlando. 2000. Exposure of Delta Smelt to Dissolved Pesticides During Larval and Juvenile Stages in 1998 and 1999. CALFED Bay-Delta Program Science Conference, Oct. 3-5, 2000, Sacramento, CA. Abstract (#183), summary and notes available at www.iep.water.ca.gov/calfed/sciconf/2000/publications/.

Moyle, P. B. 2003. Comment Letter on the Five Year Status Review of the Delta Smelt. 4 pp.

Moyle, P. B. 2002. Inland Fishes of California. University of California Press, Berkeley, California, USA.

Moyle, P. B. and J. J. Cech, Jr. 2004. *Fishes. An Introduction to Ichthyology*. 5th Edition. Prentice Hall, Upper Saddle River, NJ. 726 pp.

Moyle. P. B. and B. Herbold. 1989. The delta smelt, *Hypomesus transpacificus*. Unpublished final report prepared for U.S. Fish and Wildlife Service, Sacramento Field Office, Habitat Conservation Division, Sacramento, California. 42 pp.

Moyle, P. B., B. Herbold, D. E. Stevens, and L. W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin estuary, California. Transactions of the American Fisheries Society 121:67-77.

Moyle, P. B., R. Pine, L. R. Brown, C. H. Hanson, B. Herbold, K. M. Lentz, L. Meng, J. J. Smith, D. A. Sweetnam, and L. Winternitz. 1996. Sacramento-San Joaquin Delta native fishes recovery plan. Portland (OR): U.S. Fish and Wildlife Service.

National Marine Fisheries Service (NMFS) and U.S. Fish and Wildlife Service (USFWS). 1974. Memorandum of Understanding between the U. S. Fish and Wildlife Service, United States Department of the Interior and the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, United States Department of Commerce regarding jurisdictional responsibilities and listing procedures under the Endangered Species Act of 1973.

Nobriga, M, Z. Matica, and Z. Hymanson (2002) Assessing fish entrainment vulnerability to agricultural irrigation diversions: a comparison among native and non-native species. Interagency Ecological Program for the Sacramento-San Joaquin Estuary Newsletter. 15(3):35-44.

Poage, V. 2005. Environmental Water Account expenditures for the protection of delta smelt in Water Year 2005. Annual Review of the Environmental Water Account, Dec. 7-8, 2005, Sacramento, CA, and available at: http://science.calwater.ca.gov/workshop/ewa.shtml.

Radtke, L. D. 1966. Distribution of smelt, juvenile sturgeon and starry flounder in the Sacramento-San Joaquin Delta. Fish Bulletin 136. Sacramento (CA):California Department of the Fish and Game. P. 115-129.

Ruhl, C. A., P. E. Smith, J. J. Simi, and J. R. Burau. 2006. The pelagic organism decline and long-term trends in Sacramento-San Joaquin Delta hydrodynamics. CALFED Science Conference, October 23-25, 2006, Sacramento, CA. Abstract available at: http://sciconf.abag.ca.gov/conferences/abstract_view_01a.php

San Luis & Delta-Mendota Water Authority. 2002. The Delta Smelt and the State of the Science. 5 pp + Appendices.

Simi, J. and C. Ruhl. 2005. Summary of Delta hydrology data water years 1985-2004. In: IEP synthesis of 2005 work to evaluate the pelagic organism decline (POD) in the upper San Francisco Estuary. Available at: http://www.science.calwater.ca.gov/workshop/workshop_pod.shtml

South Delta Fish Facilities Forum (SDFFF). 2005. South Delta Fish Facilities Forum Co-Chairs Report: Some Policy Conclusions, April 20, 2005. Available at: http://calwater.ca.gov/Programs/Conveyance/SDFF/SouthDeltaFishFacilitesForum.shtml.

Souza, K. K. Hieb, K. Fleming, M. Bryant, and R. Baxter. 2005. Apparent growth rates of pelagic fishes and relation to abundance. In: IEP synthesis of 2005 work to evaluate the pelagic organism decline (POD) in the upper San Francisco Estuary. Available at: http://www.science.calwater.ca.gov/workshop/workshop_pod.shtml

Stanley, S. E., P. B. Moyle and H. B. Shaffer. 1995. Allozyme analysis of delta smelt, *Hypomesus transpacificus* and longfin smelt, *Spirinchus thaleichthys* in the Sacramento-San Joaquin Estuary, California. Copeia 1995:390-396.

State Water Resources Control Board (SWRCB). 1995. Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta estuary. State Water Resources Control Board, California Environmental Protection Agency. 95-1WR, May 1995.

Stevens, D. E. and L. W. Miller. 1983. Effects of river flow on abundance of young chinook salmon, American shad, longfin smelt, and Delta smelt in the Sacramento-San Joaquin river system. N. Am. J. Fish. Manage. 3:425-437.

Swanson, C. 2005. Effects of exports on delta smelt population abundance – preliminary analyses. Annual Review of the Environmental Water Account, Dec. 7-8, 2005, Sacramento, CA, and available at: http://science.calwater.ca.gov/workshop/ewa.shtml.

Swanson, C., T. Reid, P. S. Young, and J. J. Cech, Jr. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered California estuary. Oecologia 123:384-390.

Swanson, C., P. S. Young, and J. J. Cech, Jr. 2005. Close encounters with a fish screen: integrating physiological and behavioral results to protect endangered species in exploited ecosystems. Transactions of the American Fisheries Society 134:1111-1123.

Teh, S. J. 2005. Histopathological evaluation of starvation and/or toxic effects on pelagic fishes. In: IEP synthesis of 2005 work to evaluate the pelagic organism decline (POD) in the upper San Francisco Estuary. Available at: http://www.science.calwater.ca.gov/workshop/workshop_pod.shtml

Thompson, J. K and F. Parchaso. 2006. Foodweb support for the threatened delta smelt: grazing potential of *Corbula amurensis* on lower trophic level. CALFED Science Conference, October 23-25, 2006, Sacramento, CA. Abstract available at: http://sciconf.abag.ca.gov/conferences/abstract_view_01a.php

Trenham, P. C., H. B. Shaffer, and P. B. Moyle. 1998. Biochemical identification and assessment of population subdivision in morphologically similar native and invading smelt species (*Hypomesus*) in the Sacramento-San Joaquin estuary, California. Transactions of the American Fisheries Society 127:417-424.

U.S. Fish and Wildlife Service (USFWS). 1993. Determination of Threatened Status for the Delta Smelt. 58 FR 12854 12864, March 5, 1993.

U.S. Fish and Wildlife Service (USFWS). 1994. Critical Habitat Determination for the Delta Smelt. 59 FR 65256 65279, December 19, 1994.

U.S. Fish and Wildlife Service (USFWS). 1996. Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes.

U.S. Fish and Wildlife Service (USFWS). 1999. Determination of Threatened Status for the Sacramento Splittail. 64 FR 5963, 5974-80, Feb. 8, 1999.

U.S. Fish and Wildlife Service (USFWS). 2004. 5-Year Review, *Hypomesus transpacificus* (delta smelt). U. S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California.

U.S. Fish and Wildlife Service (USFWS). 2005. Formal and Early Section 7 Endangered Species Consultation on the Coordinated Operations of the Central Valley Project and State Water Project and Operational Criteria and Plan. U. S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office, Sacramento, California.

U.S. Geological Survey (USGS). 2003. Editor's Comments-Peer Review of the 2002 San Luis and Delta-Mendota Water Authority White Paper "The Delta Smelt and the State of the Science."

U. S. Bureau of Reclamation (USBR). 2004a. Long-term Central Valley Project Operations Criteria and Plan. Department of Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA. June 30, 2004. 238 pp. and appendices.

U. S. Bureau of Reclamation (USBR). 2004b. Long-term Central Valley Project Operations Criteria and Plan, Biological Assessment. Department of Interior, Bureau of Reclamation, Mid-Pacific Region, Sacramento, CA. June 30, 2004. 776 pp. and appendices.

Attachment 13

# Finding the Water

## NEW WATER SUPPLY OPPORTUNITIES TO REVIVE THE SAN FRANCISCO BAY-DELTA ECOSYSTEM

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ENVIRONMENTAL DEFENSE

finding the ways that work

# Finding the Water

## NEW WATER SUPPLY OPPORTUNITIES TO REVIVE THE SAN FRANCISCO BAY-DELTA ECOSYSTEM


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ENVIRONMENTAL DEFENSE

finding the ways that work

*Cover image:* Thomas B. Dunklin (salmon), California Department of Water Resources (river)

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# Contents


**Executive summary** iv

**Chapter 1: Introduction** 1
Historical impacts on the estuary 2
A declining resource 3

**Chapter 2: Overview of environmental water requirements** 5
CALFED and the EWA 5
CVPIA and the Anadromous Fish Restoration Program 7
The Bay-Delta Accord and the WQCP 8

**Chapter 3: Where are we today? Five years of CVPIA and EWA implementation** 10
Diminished CVPIA fisheries commitments 10
Diminished EWA 12

**Chapter 4: Future funding prospects are highly uncertain** 16

**Chapter 5: Opportunities for greater environmental protection** 17

**Chapter 6: Conclusion** 20

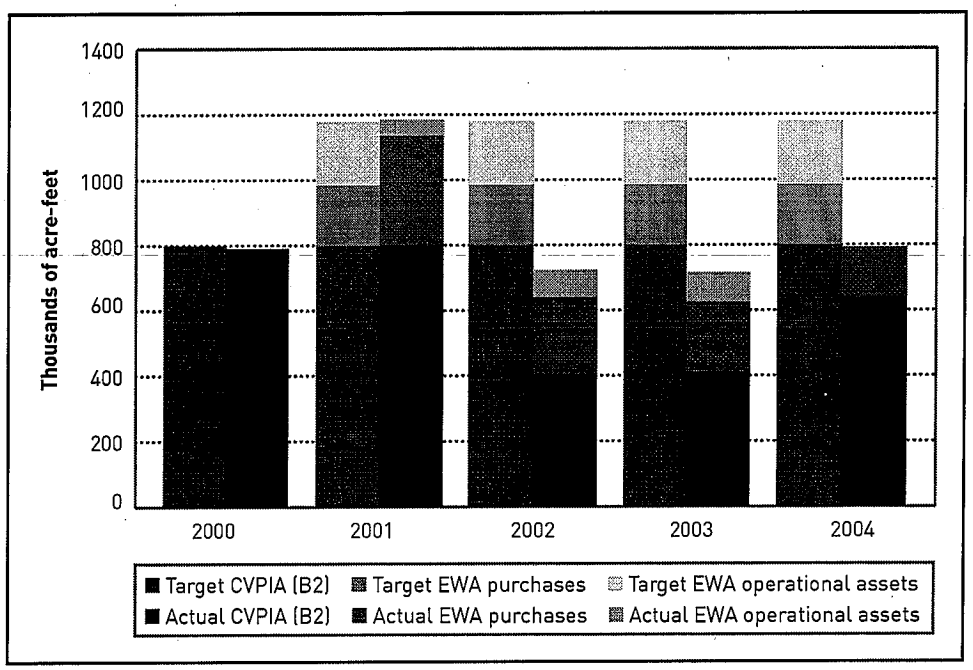
**Notes** 21

# Executive summary

The San Francisco Bay-Delta is in crisis. Fish populations have dropped to record lows in the West Coast's largest estuary, which is a source of drinking water for 22 million California residents and supplies irrigation water for much of the state's agriculture industry. Now, new threats are on the horizon as the state of California plans to increase the capacity of its export pumps to divert even greater volumes of fresh water out of the Delta. At the same time, environmental water targets set forth in the CALFED Plan (specifically those of the Environmental Water Account [EWA] and the Central Valley Project Improvement Act [CVPIA]), intended to protect and restore the estuary and lessen the impacts of water project operations, have not been met for the last three years and face an uncertain future. If the Bay-Delta is to be restored, it is imperative that managing agencies follow through on their commitments to provide environmental water. Meeting the environmental water objectives set forth in the CALFED Plan is an essential element in restoring not only the estuary but also in renewing public confidence in our water management agencies.

In this study, Environmental Defense concludes, based on analysis of water operations data, that in the past few years the environment has been underendowed by approximately 420,000–460,000 acre-feet annually (Figure ES-1)

FIGURE ES-1
**Unmet environmental water targets, 2000–2005**




Since 2002, the EWA and CVPIA have been under endowed on average by 436,000 acre-feet. The EWA, which began in 2001, has seldom had adequate assets (i.e., water) available largely due to limited funding. CVPIA supplies began diminishing after the Interior Department's 2003 Decision (already in place in 2002), which offered far less protection than the previous policy. Current trends indicate that neither the EWA nor CVPIA water supplies are likely to be available in 2005 and beyond, as intended in the CALFED Plan, unless significant changes are made.

Source: California Department of Water Resources, U.S. Bureau of Reclamation

CALIFORNIA DEPARTMENT OF WATER RESOURCES

The San Francisco Bay-Delta is the hub of California's water supply system. In recent years, the health of this important estuary has significantly declined and populations of key fish species have dropped to record lows. Now additional threats are on the horizon as the State of California plans to increase the capacity of Delta freshwater exports.

The shortfalls in water dedicated to environmental protection are largely due to diminished state and federal funding, unavailable operational assets through the EWA and revised accounting rules for environmental water under the CVPIA. As a result, fishery agencies have been significantly constrained in their ability to dedicate water at key times of the year to protecting fisheries—particularly endangered species—as promised in the CALFED Plan.

Fortunately, as actions are taken to modify and modernize water management in California, there will be opportunities for obtaining the water necessary to provide environmental protection. In this report, Environmental Defense identifies key opportunities to acquire water to finally realize the protective assurances promised in the CALFED Plan. These opportunities include:

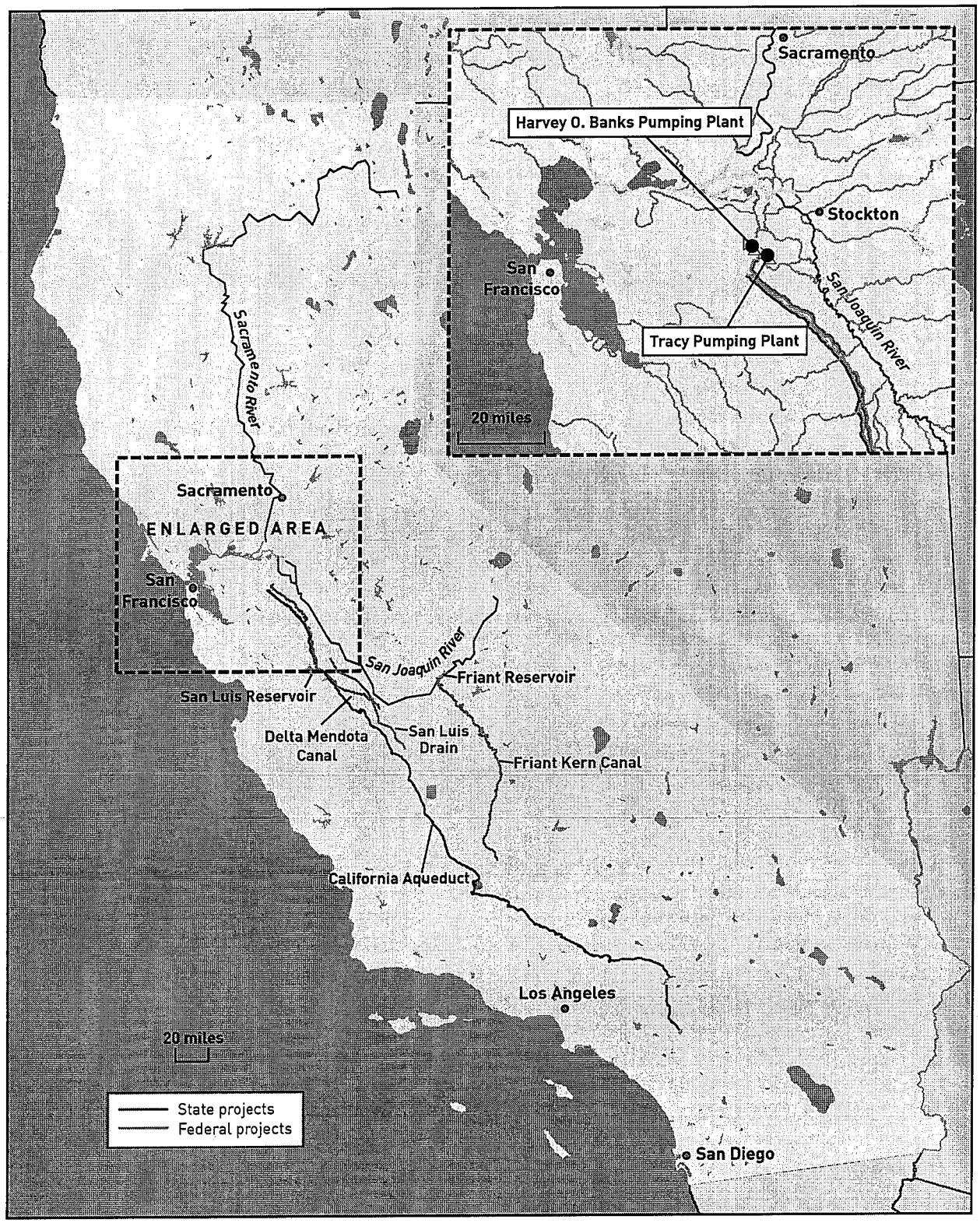
- Increasing the usable storage in San Luis Reservoir
- Dedicating increased export capacity
- Integrating state and federal water projects
- Restoring the CVPIA's commitments to fisheries protection and restoration
- Implementing CALFED's Environmental Water Program (EWP) and Section B3 of the CVPIA
- Retiring drainage-impaired land in the San Joaquin Valley
- Implementing user fees

To ensure sustainable and reliable supplies, the water acquired through these opportunities could be required as part of the regulatory standards to which the water projects must adhere. As such, these regulatory standards could help protect fisheries by allowing pumping *only* when it is safe for fish, similar to both EWA and CVPIA protections.

With some creativity and foresight, it is possible to address the problems in the Bay-Delta. The health of the estuary largely depends on a reliable set of environmental safeguards, including dedicated water supplies. In order to ensure the availability of sustainable water supplies, a plan must be developed that identifies long-term supplies, provides assurances that water will be supplied and includes consequences for noncompliance. In light of the dire condition of the Bay-Delta and the looming threat of increased freshwater diversions, government agencies, water contractors and the interested public need immediately to develop a viable plan to assure adequate fresh water supplies for the long-term health of the San Francisco Bay-Delta.

FIGURE 1

**The San Francisco Bay-Delta: the hub of California's water system**




The San Francisco Bay-Delta is one of California's most valuable and unique ecological resources. The Bay-Delta also supplies drinking water for 22 million California residents and irrigation water for much of the state's agricultural industry via the state and federal pumping facilities, Harvey O. Banks and Tracy, respectively.

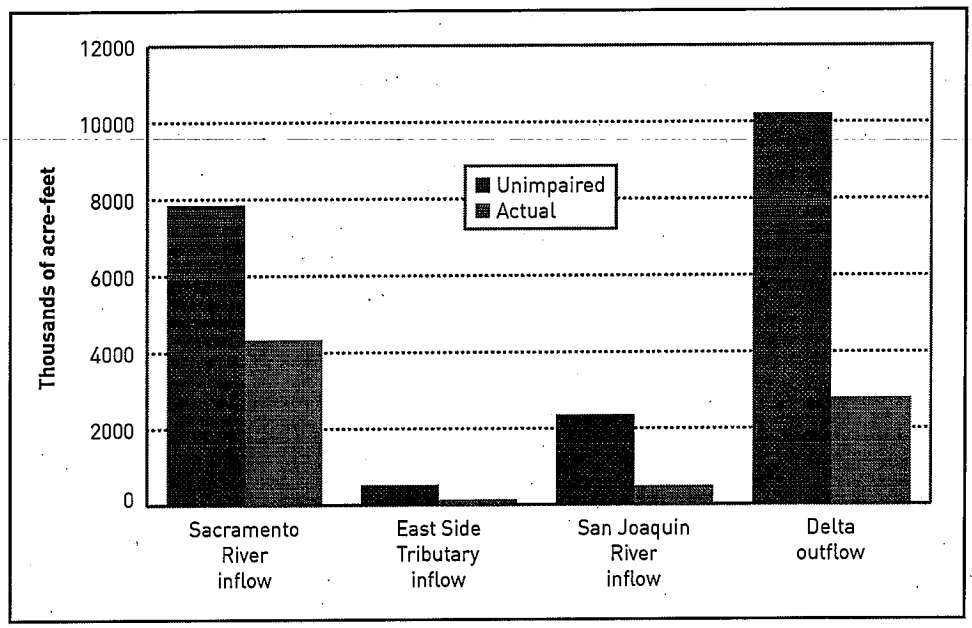
CHAPTER 1

# Introduction

The San Francisco Bay-Delta Estuary has been the hub of California's water supply system since the state's early days when farmers first diverted its freshwater inflows to grow food for hungry gold miners. As the state has grown, the Delta has become the center of a water system delivering supplies from the wetter northern region to the more populous and drier southern region. As Figure 2 shows, land conversion, water development and flood control projects throughout the Central Valley have drastically altered freshwater flows in the estuary.

Since the completion of Friant Dam in the 1940s, most years the entire flow of the upstream reaches of the San Joaquin River is diverted, leaving a dry riverbed upstream of its confluence with the Merced River. In 1956, the federal Central Valley Project (CVP) began to export large volumes of water into the Delta Mendota canal to assist farmers along the San Joaquin River whose supplies had been diverted south by the Friant project, as well as to support expanded agriculture on the arid west side of the San Joaquin Valley. Figure 3 illustrates how Delta exports have grown over the last 50 years. Exports sharply increased in the late 1960s, when the California State Water Project (SWP) was completed, principally to provide additional water supplies to urban southern California and the agriculture industry in Kern County. At the same time, the CVP completed its San Luis Unit, including a contract for more than 1,000,000 acre-feet with the Westlands Water District. Exports of fresh water steadily increased until 1991, when a lengthy drought forced their reduction.

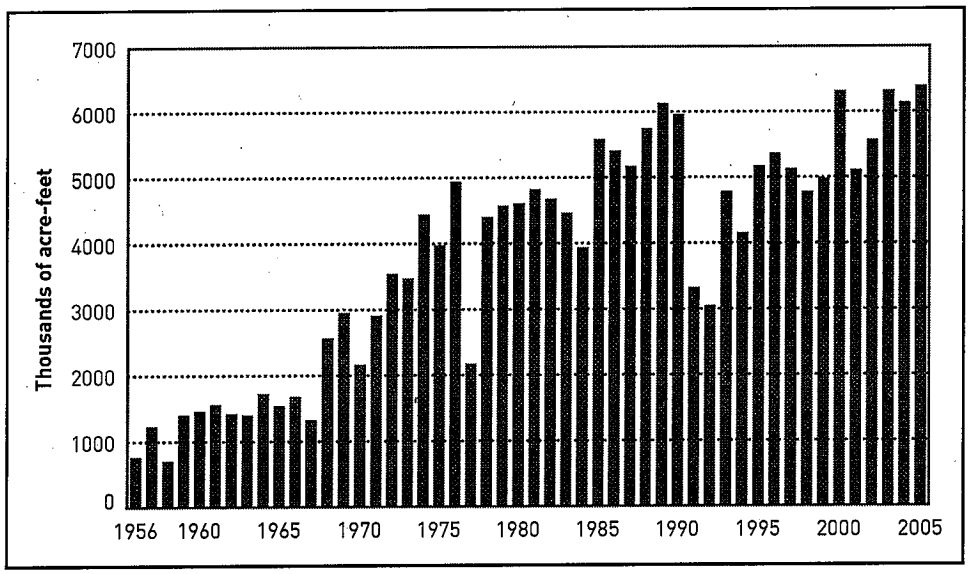
FIGURE 2
**Changes to Delta flows, February–June, 1987–1992 drought**




Land conversion, water development and flood control projects throughout the Central Valley have altered the volume and timing of flows into and out of the estuary. The changes are particularly noticeable in dry years such as the 1987–1992 drought.

Source: California Department of Water Resources, Interagency Ecological Project

FIGURE 3
**Historic Delta exports, 1956–2005**




In recent years, both state and federal exports have been steadily rising, with three out of the past five years reaching record highs, and an all-time high of 6.4 million acre-feet was reached in 2005.
Source: California Department of Water Resources

Exports are once again on the rise, reaching the highest levels ever in three out of the past five years, with an all-time high of 6.4 MAF at the export pumps in 2005.

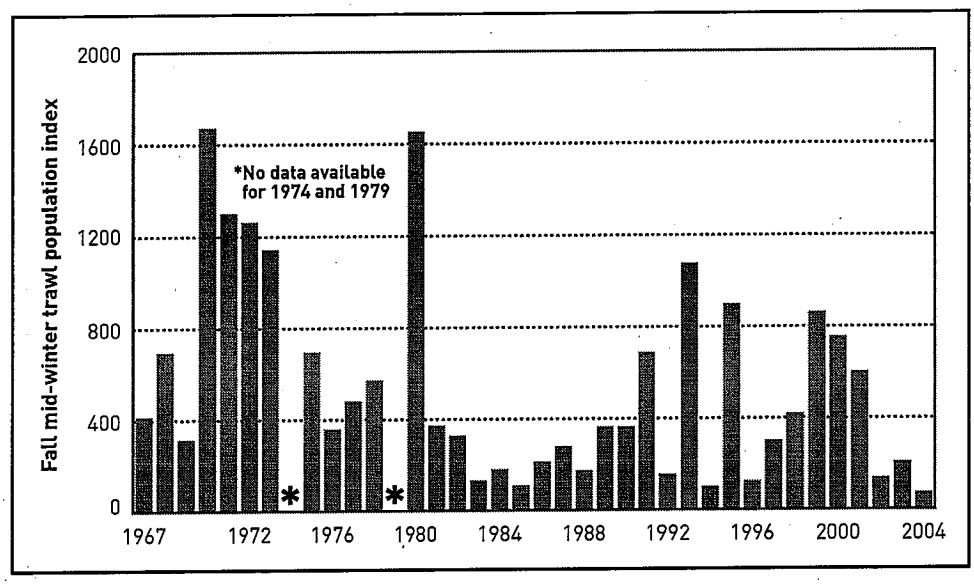
## Historical impacts on the estuary

As the physical and ecological processes in the Bay-Delta system have changed, the estuary's fisheries have been devastated. By the late 20th century, the overall decline of the aquatic environments in the Central Valley and Bay-Delta was apparent. The winter-run Chinook salmon population had, until 1978, always been measured in the tens of thousands, but was down to 191 fish returning in 1994. Populations of

BRANDON D. COLE/CORBIS

Human demands on the Bay-Delta system have strained the species dependent on it. Chinook salmon spend most of their lives in salt water, but they spawn and hatch in freshwater streams. The winter-run Chinook salmon population had, until 1978, always been measured in the tens of thousands, but was down to 191 returning fish in 1994.

FIGURE 4
**Historic Delta smelt abundance, 1967–2004**




The protective mechanisms of the WQCP, the CVPIA and the EWA are in place to protect sensitive species such as Delta smelt, an estuarine fish found only in the Bay-Delta. Populations of Delta smelt, listed under the Endangered Species Act a decade ago, are at the lowest levels ever, down from a population index of 864 in 1999 to 74 in 2004. Source: California Department of Fish and Game fall mid-water trawl

both the Bay-Delta's resident fish and the salmon and steelhead that passed through the Delta en route to and from spawning grounds in Central Valley streams showed similar trends. Shortly after a severe drought from 1987–1992, a number of species were listed for protection under the state and federal Endangered Species Acts. The listing of Delta smelt is of special concern as its one-year life cycle makes it particularly vulnerable to extinction. One year of very low numbers could be devastating to the smelt population. Initial Endangered Species Act listings include:

- Winter-Run Chinook, Endangered, California ESA, September 22, 1989
- Delta Smelt, Threatened, Federal ESA, March 5, 1993
- Steelhead, Threatened, Federal ESA, May 18, 1998
- Spring-Run Chinook, Threatened, California ESA, February 6, 1999
- Splittail, Threatened, Federal ESA, March 10, 1999 (subsequently removed)

## A declining resource

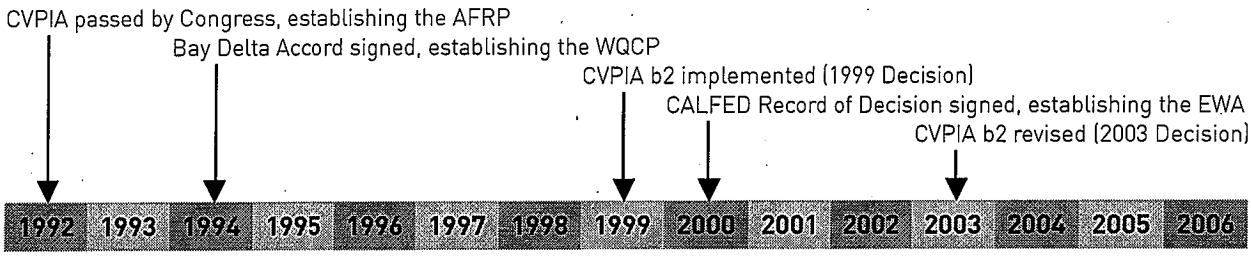
In recent years, the health of the Bay-Delta ecosystem has become increasingly precarious and new threats are on the horizon, in particular the proposed increase in capacity to export water from the Delta. As exports have continued to rise, recent surveys have shown a sharp decline in populations of estuarine fish. Delta smelt, listed under the Endangered Species Act a decade ago, are at their lowest level ever (Figure 4).[1] In addition, juvenile striped bass are at their lowest levels in four decades and both longfin smelt and threadfin shad populations are reaching near-record lows.[2] Contributing to these declines is a sharp reduction in the abundance of zooplankton, particularly a calanoid copepod, which is the primary food for young estuarine fish as

well as older life stages of Delta smelt. The Interagency Ecological Program, a collaboration of state and federal agencies focusing on the ecology of the Bay-Delta estuary, is currently conducting a comprehensive review of the possible causes of this most recent decline in Delta fisheries. The program will specifically investigate the degree to which pollution, invasive species and water project operations are responsible for the decline.

CHAPTER 2

# Overview of environmental water requirements

### Timeline of environmental water requirements




In response to the declining condition of the Bay-Delta in the 1990s, a number of environmental water requirements were developed to lessen the impacts of the water projects. These requirements were designed to provide increased instream flows or curtail export pumps at key times to protect fisheries. Today, three important requirements fall under the plan developed in 2000 by the state-federal CALFED Bay-Delta Authority.[3] In particular, the CALFED Plan provides three tiers of protection which include the Environmental Water Account (EWA), the Central Valley Project Improvement Act (CVPIA) and the Water Quality Control Plan (WQCP). An overview of these three environmental water requirements follows.

## CALFED and the EWA

In 1995, to address the conflict over competing human demands in the Delta and declining fisheries, state and federal agencies, water contractors, public interest and environmental groups and others went to work on a long-term plan. Many elements of the vast program under CALFED's purview were contentious, though perhaps none so much as the rules governing export pumping. Fishery agencies and environmentalists asserted that additional protections were needed to reduce exports, especially when at-risk populations were in the vicinity of the pumps. Others agreed that some additional protection was necessary but pointed out that it was not always possible to identify in advance when export curtailments to protect fish from direct entrainment would be needed.

At the behest of then-Secretary of Interior Bruce Babbitt, CALFED agencies and stakeholders were tasked to find a mechanism for applying export reductions on a real-time basis, rather than on a fixed schedule. The idea was that the most efficient way to balance competing objectives for water export and environmental protection was not to determine in advance when exports ought to be curtailed to reduce fish mortality, but to provide a mechanism whereby fishery scientists with detailed monitoring capabilities could request reductions when fish would otherwise be entrained in large numbers at the export pumps.

After months of comprehensive "gaming" exercises, during which fishery scientists, project operators and others simulated how such real-time changes to project operations might be accomplished in response to monitoring data, a plan for the EWA emerged. Successfully negotiating the EWA was a key component that allowed the final CALFED Plan to be released in 2000.

The EWA was adopted as a water management tool intended to protect endangered fish from the harmful operational impacts of the federal and state water projects without reducing existing water supply or deliveries from the Delta. In general, U. S. Fish and Wildlife Service (FWS), National Marine Fisheries Service (NMFS), and California Department of Fish and Game (DFG) would act as management agencies, using monitoring data, scientific understanding and professional judgment to decide which actions were required to protect and recover Delta fish populations and ecosystem function. The U.S. Bureau of Reclamation and California Department of Water Resources (DWR) would act as the project agencies that oversee the operation of the EWA and implement those actions deemed necessary by the fishery agencies. EWA water supplies would be acquired either through applying a set of different tools used to gain supplies during system operations (i.e., operational assets) or through purchases (i.e., purchased assets) (Table 1).

The EWA would protect fish from mortality due to entrainment in the pumps and ensure reliable supplies for the water contractors while providing them with near-absolution from additional compliance with the Endangered Species Act. Without the EWA in place, additional pumping would increase the number of fish "taken" at the pumps, thereby increasing the likelihood of ESA non-compliance for water contractors. The EWA is thus effectively an insurance policy for water contractors—providing substantial economic benefits by assuring reliable supplies without fear that the

### CALFED's three tiers of environmental protection

**Tier 1:** Consists of regulatory requirements including Delta smelt and winter-run Chinook salmon biological opinions, WQCP and 800,000 acre-feet of supplies pursuant to CVPIA Section 3406(b)(2).

**Tier 2:** Comprised of environmental benefits provided by the EWA and Ecosystem Restoration Program. Tier 2 is a mechanism to assure that water is provided for fish protection and recovery, without a reduction in deliveries to water users.

**Tier 3:** Founded on the commitment of state and federal agencies to make additional water available if the combined protections of Tier 1 and 2 were inadequate to protect ESA-listed species.[4]

TABLE 1
**Proposed sources of water for the EWA**

| Action description | Water available annually (average) |
|---|---|
| **Operational assets** | **195,000 acre-feet** |
| SWP pumping of (b)(2)/ERP upstream releases | 40,000 acre-feet[2] |
| EWA use of joint point | 75,000 acre-feet |
| Export/inflow ratio flexibility | 30,000 acre-feet |
| 500 cfs SWP pumping increase | 50,000 acre-feet |
| **Purchased assets** | **185,000 acre-feet** |
| Purchases—south of Delta | 150,000 acre-feet |
| Purchases—north of Delta | 35,000 acre-feet |
| **Total** | **380,000 acre-feet** |

Source: CALFED Record of Decision

Endangered Species Act will diminish their supplies.

The CALFED Plan describes the EWA as the second of three "Tiers" of environmental water supplies (see sidebar). Tier 1 includes regulatory requirements that were already in place, including the WQCP, CVPIA supplies and rules for project operations, to protect Delta smelt and winter-run Chinook salmon under the Endangered Species Act. Given that the EWA would interact so closely with actions taken pursuant to the CVPIA, the CALFED Plan made clear that Tier 1 would include CVPIA supplies that were available under the federal policy for B2 supplies established in 1999 by the Department of the Interior.

During CALFED's gaming process, agency staff projected that an annual average of 195,000 acre-feet would be available for the EWA in the normal course of CVP and SWP operations (Table 1). Additionally, agencies elected to commit to purchasing supplies amounting to 185,000 acre-feet per year. Together, these operational and purchased assets would total 380,000 acre-feet per year on average.

In exchange for CALFED's three-tiered suite of protections, the fishery agencies agreed that they would require no further reductions beyond existing regulatory levels in CVP or SWP Delta exports for the protection of state and federally listed, threatened and endangered species. In essence, the water users were guaranteed a reliable supply of water, without unscheduled interruptions due to compliance with the Endangered Species Act. These ESA commitments were to be renewed annually and were contingent on full funding and availability of the three tiers of protections.

## CVPIA and the Anadromous Fish Restoration Program

Prior to the EWA, Congress passed the CVPIA in 1992, largely in response to the ecosystem decline in the Bay-Delta and Central Valley watersheds. The Act made protection of fish and wildlife a priority and included a directive to achieve a reasonable balance between the requirements of fish and wildlife and other project purposes. The CVPIA contains a number of landmark provisions that substantially modify and

The Sacramento River and the San Joaquin River are the two main tributaries that flow into the Bay-Delta. Of the two, the Sacramento River provides the bulk of outflow to the Bay and is a critical spawning habitat for winter-run Chinook salmon.

modernize the CVP, including directives to provide additional water for the benefit of fisheries and wetlands in the Central Valley and Bay-Delta.[5]

The Act's most controversial element has been its Anadromous Fish Restoration Program (AFRP) and the subsequent authorization to modify water project operations to accomplish its goal of doubling anadromous fish populations by 2002.[6] To implement the AFRP, the Act provides three water management tools. The authorized modifications are usually referred to as B1, B2 and B3 supplies, named after the sections of the law in which they appear. In short:

- Section B1 instructs the CVP to modify project operations for fish protection as long as the timing and volume of deliveries of the Project's contractors are not impaired.
- Section B2 annually dedicates 800,000 acre-feet of the Project's water supplies for fish protection.
- Section B3 provides funding for additional flow purchases by levying a surcharge on water users.[7]

Due to its controversial nature, Section B2 was not fully implemented until seven years after the CVPIA had passed. In October 1999, the U.S. Department of the Interior released a final decision for administering Sections B1 and B2 jointly. Its principal provisions included measuring reservoir releases that were increased to improve conditions for fisheries on four federally controlled streams (Sacramento River, Clear Creek, American River and Stanislaus River), as well as any curtailments that were made at the Delta export facilities to reduce entrainment of fish in the pumps. Under most circumstances, these flow increases and export reductions were based on the cumulative net change to CVP operations during the course of a water year. The 1999 Decision also, in recognition of the Act's primary purpose of doubling anadromous fish populations, insisted that a significant portion of the CVPIA's B2 dedication be applied to protect salmon habitat on CVP-controlled streams for spawning and rearing, rather than simply providing safe passage through the Bay-Delta.

## The Bay-Delta Accord and the WQCP

As the U.S. Department of the Interior struggled to implement the CVPIA, efforts to deal directly with the Bay-Delta's ecological problems continued. After the State of California withdrew from its own effort to develop alternative regulation for water project operations, the U.S. Environmental Protection Agency (EPA) threatened to promulgate water quality standards under the Clean Water Act.[8] Responding to this warning, federal and state agencies, water contractors and environmentalists negotiated a package of environmental protections, operations protocols and funds for habitat restoration. On December 15, 1994, state and federal agencies, joined by ten "interested parties" including Environmental Defense, signed the Bay-Delta Accord. The Accord established interim standards for water project management and encouraged parties to work together on a long-term solution. As a result, the state and federal government initiated the CALFED program, with a mandate of developing long-term solutions that would address water supply, water quality, levee stability and ecosystem issues facing the Delta.

The SWP and CVP agreed to bear the full responsibility for meeting the Accord's flow objectives, with the

expectation that the State Water Resources Control Board (SWRCB) would consider whether other water agencies should also provide flows for the Delta.[9] According to the agreement, the majority of this burden would be met by the CVP, using a portion of its B2 account. The SWP's contribution to the Accord's objectives was smaller on average, but significant in wet years. The Accord's objectives would be implemented as the newly-formed CALFED Program worked on a long-range plan.

The Bay-Delta Accord's standards were formally adopted in 1995 by the SWRCB as the WQCP for the San Francisco Bay and Sacramento-San Joaquin Delta Estuary. In particular, the WQCP limits state and federal export pumping to 35% of Delta inflow during February through June when estuarine fish breed, and to 65% of inflow during the rest of the year. The WQCP also implemented the Accord's "X2" recommendations for Delta outflow through requirements for low-salinity habitat during the February through June period.[10] In any given month during this period, Delta outflow requirements are determined based on the natural flows of the eight largest rivers in the Sacramento and San Joaquin Valleys.

Most elements of the WQCP have been incorporated by the SWRCB in its water rights orders. As a result, the WQCP's outflow requirements, export curtailments and Sacramento River inflow requirements are met annually through the operation of the CVP and SWP. The WQCP's inflow objectives for spring inflow to the Delta from the San Joaquin River, however, are only partially met by compensated contributions from local water agencies as part of the Vernalis Adaptive Management Plan.[11]

CHAPTER 3

# Where are we today? Five years of CVPIA and EWA implementation

While some salmon populations have improved considerably, largely in response to improved instream flows in upstream tributaries and removal of upstream passage impediments, the Delta's estuarine fish are faring poorly. Populations of Delta fisheries have hit record lows at a time when project exports have reached record high levels. At the same time, the guarantees of environmental water envisioned in the CALFED Plan have fallen short of their objectives. As a consequence, the ability of fishery agencies to manage Delta exports through application of the CVPIA and EWA supplies has been significantly compromised. The following is an overview of the CVPIA's and EWA's performance and an estimate of how much the environment has been underendowed.

## Diminished CVPIA fisheries commitments

Changes in the application of the CVPIA have significantly reduced its ability to protect fish both upstream and in the Delta. As a consequence, the EWA is now expected not only to do the job intended for it when the CALFED Plan was adopted but also to make up the water lost when the CVPIA's protections were weakened.

Though it was incorporated as a cornerstone of the CALFED Plan, the Interior Department's 1999 Decision for administering Sections B1 and B2 jointly was in force for only two years—2000 and 2001—after it was signed. During this period, only the annual increased use of CVP supplies for fishery enhancement, in terms of either additional reservoir releases for streamflow or export curtailment to reduce entrainment, was counted toward the CVPIA's 800,000 acre-feet of yield, as defined by Section 3406(b)(2). Occasions in which flow increases were subsequently "offset" by flow decreases, or vice versa, were attributed to the "reoperation" authorized by CVPIA Section B1, pursuant to the CVPIA, as they did not affect water contractors. Similarly if winter storms followed fishery actions and reservoir storage was "reset" as a result, the operational change was attributed as a reoperation and not charged to the B2 account. Also, in 2001, the 1999 Decision's provision that no more than 450,000 acre-feet of the 800,000 acre-feet B2 account would be charged to meet Delta obligations (i.e. WQCP standards), was applied. As a result, an additional 75,000 acre-feet of environmental water was purchased with CALFED funding.

The Interior Department's 1999 Decision was not to last, however. In 1997, CVP contractors initiated litigation against the United States challenging the Interior Department's initial interpretation of Section 3406(b)(2). Various environmental groups, including Environmental Defense, and fishing groups joined the suit soon thereafter. The U.S. District Court eventually ruled on a complex series of issues involving various Department of Interior decisions over a five-year period.

In January 2002, the court issued key rulings that forced Interior to revise its policies for "offset" and "reset." As a result, virtually all operational changes implemented to improve fisheries would be charged to the B2 account, even if the changes had no effect on con-

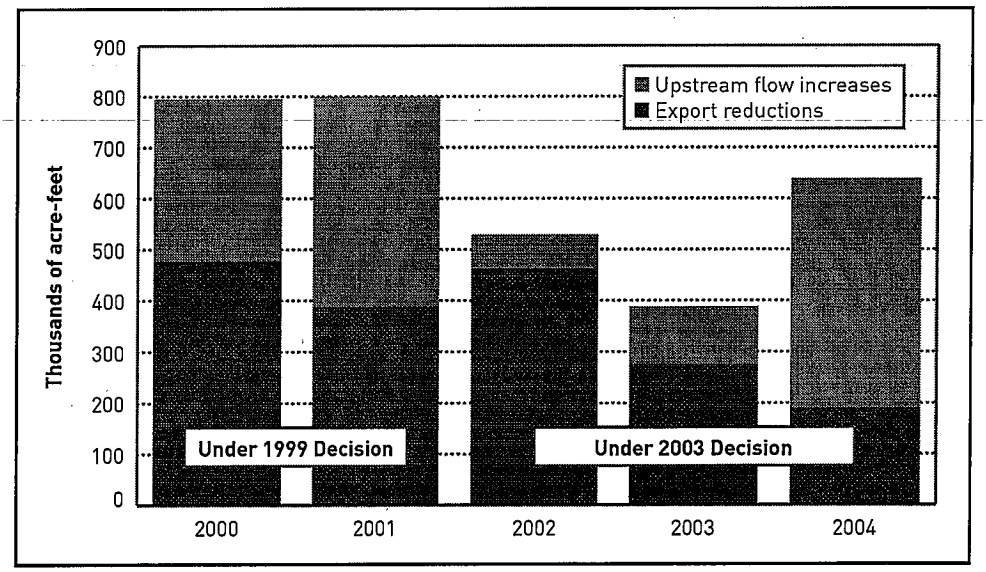
tractors. The ruling did not address how Interior should apply the fishery provisions in Section 3406(b)(1) which authorize the Secretary "to provide flows of suitable quality, quantity, and timing to protect all life stages of anadromous fish" as long as they "do not conflict with fulfillment of the Secretary's remaining contractual obligations to provide Central Valley Project water for other authorized purposes". In addition, the court ruled that the Interior Department had no discretion to limit how much of the B2 account could be used in meeting its share of WQCP obligations.[12] The effect of these rulings meant that, in many years, the entire B2 account might be applied to meet the WQCP obligations within the Delta, leaving no water to enhance spawning and outmigration of anadromous fish.

The Interior Department's 1999 Decision for use of CVPIA supplies was unofficially displaced in 2002 by a new policy incorporating the court's rulings. In 2003, Interior formally adopted a new policy that included not only the ruling but also further diminished how much environmental water it would provide in dry years. The 2003 policy allows water delivered to CVP contractors to be counted as water dedicated to fisheries protection.

Under the 2003 policy, the Fish and Wildlife Service is forced to make difficult choices with its limited B2 supplies between taking upstream actions to protect anadromous fish, or in-Delta actions to reduce direct entrainment. In 2002, for example, approximately 331,000 acre-feet was charged to the B2 account that would not have been charged under the 1999 policy (Figure 5).

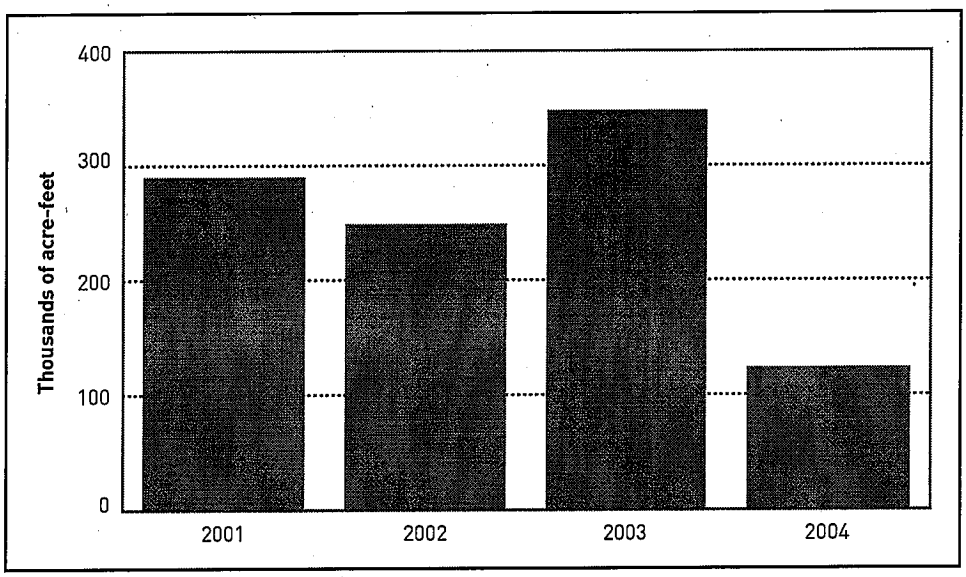
The court rulings and the Interior Department's revised policy have

FIGURE 5
**Changes in Central Valley Project Improvement Act environmental "b2" water supplies**




The Interior Department's 2003 change in policy for applying the CVPIA's environmental water significantly reduced the amount of water provided to protect and restore fisheries. This change has undermined the protections provided in the CALFED Plan and has put additional pressure on the EWA.
Source: U.S. Bureau of Reclamation provided daily operational data as well as the B2 accounting under its various policies. Environmental Defense applied the Bureau's accounting policy under its 1999 Decision to the 2002–2004 project operations.

FIGURE 6
**Environmental Water Account export reductions to protect fisheries, 2001–2004**




The EWA is principally used to curtail exports for the benefit of threatened Delta fish species. Since 2001, the ability of the EWA to do its job has been limited due to inadequate acquisition of both operational and purchased assets.
Source: CALFED EWA Team, a multi-agency stakeholder group helping to coordinate the implementation of the EWA.

effectively reduced CALFED's Tier 1 capabilities to near zero. As a result of these changes, the EWA has been expected not only to do the job intended for it as part of the CALFED Plan but also to make up the water lost as a result of the court's and the Interior Department's interpretations of the CVPIA.

## Diminished EWA

The EWA has had significantly less water than expected to do its job. Combined, the CVPIA and EWA have been underendowed by an average of 436,000 acre-feet over the past three years.[13] Yet, the need for a sustainable and reliable supply of environmental water, in the context of both record levels of high exports and low fish populations, is even more important today.

The EWA was created as an innovative tool intended to solve some of the serious ecosystem problems in the Delta. Unfortunately, due to a combination of insufficient operational assets and dwindling funding, early on the EWA was effectively robbed of some of its potential (Figure 6). As a result, in its four years of operations, the EWA has received mixed reviews.

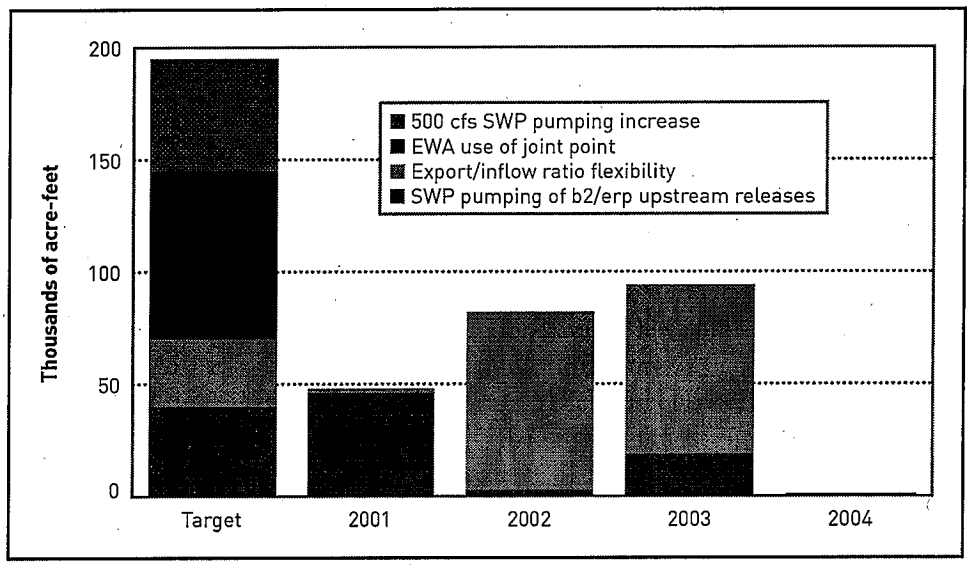
From an operational perspective, the EWA has worked well to ensure reliable supplies to water users and has had some positive effects on the Delta's aquatic habitat. EWA purchases, when executed, have provided some environmental protection, which CALFED's EWA Technical Review Panel has noted as one of the most effective elements of the program.[14] There have been various examples of fishery scientists using EWA supplies effectively to provide additional Delta inflows or decreasing export pumping to improve estuarine conditions.

Unfortunately, however, the EWA has never received the amount of water anticipated by the CALFED Plan. On average, only 29% of the expected

195,000 acre-feet of operational assets have been available. The initial assumptions from CALFED's gaming process that preceded the EWA, projecting the EWA could expect significant supplies through the normal course of project operations, have proven overly optimistic (Figure 7).

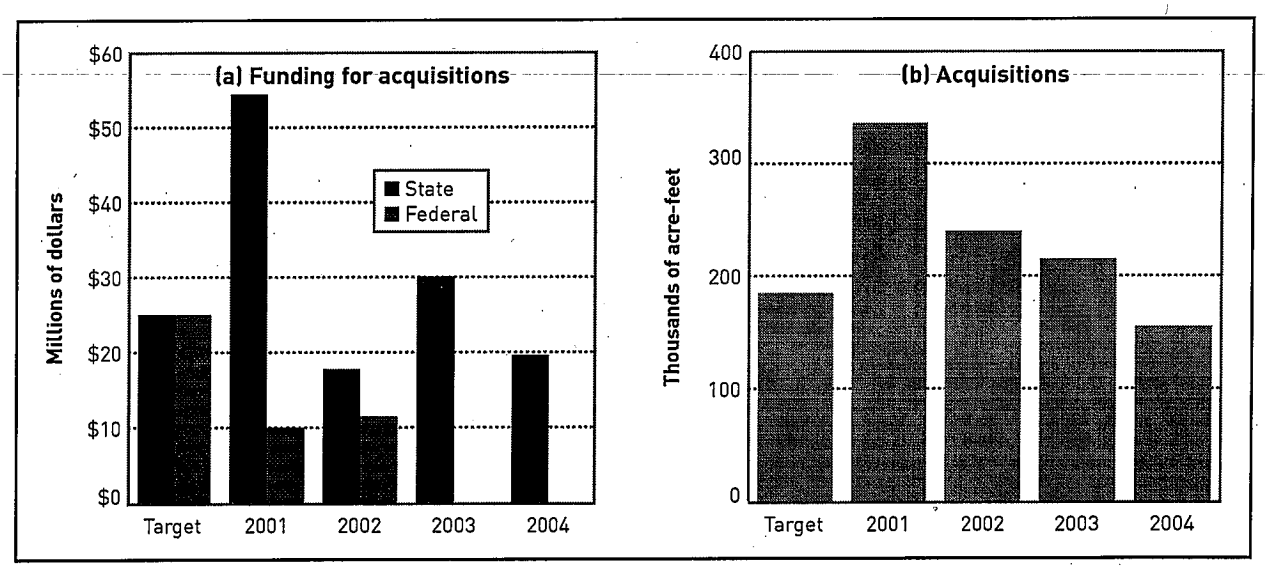
As a consequence, the EWA has had to rely almost entirely on purchases

FIGURE 7
**Environmental Water Account operational assets, 2001–2004**




The CALFED Plan targeted 195,000 acre-feet of operational assets for the EWA. Since 2001, many types of operational assets have seldom been available and have, on average, only produced 29% of the target. Source: California Department of Water Resources, CALFED Plan

FIGURE 8
**The Environmental Water Account**

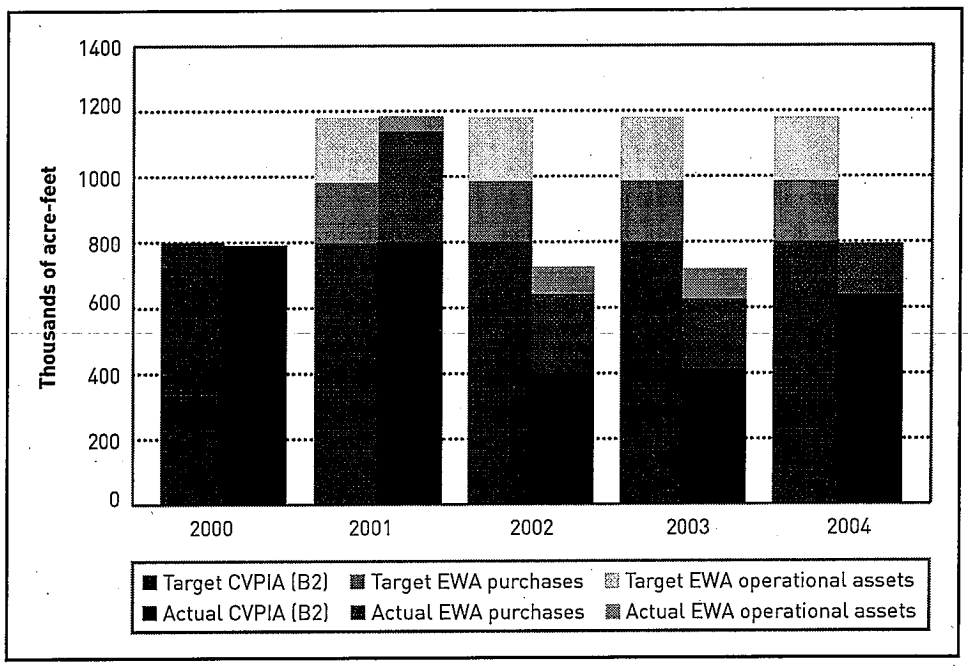



(a) The CALFED Plan targeted a 50/50 cost-sharing goal for the EWA among state and federal sources. Since 2001, however, the state has covered the majority of the EWA's costs. The state sources, comprised of various propositions, are running out and it is unlikely that the state will be able to continue to fund the EWA. (b) In the absence of available operational assets, the EWA has had to rely heavily on purchased assets to acquire water.[15] Source: California Department of Water Resources, U.S. Bureau of Reclamation

from willing sellers to acquire its supplies.[16] This approach worked well the first few years when significant bond funds were available to endow the EWA with purchasing power.[17] As these various bonds, including Proposition 50, run out, it is uncertain how the EWA will be funded in the future (Figure 8). Without extensive changes, future prospects for a fully endowed EWA look poor, given the state's budget crisis and exhausted bond funding.

Dwindling assets have limited the EWA's ability to do its job. In a typical year, most EWA actions to protect fisheries are taken by curtailing export pumping to reduce entrainment and increase survival. Other actions have been taken to supplement upstream flow releases for spawning and to control water temperature. In recent years, the EWA has increasingly been unable to achieve desired fish actions, despite growing evidence of declining fish populations. In 2004, the only fish actions taken were to implement the Vernalis Adaptive Management Plan and extend its protections into the late spring. More recently, in February 2005, after monitoring indicated that Delta smelt populations were at record low levels, fishery biologists recommended that exports be curtailed to reduce entrainment. Agency managers, keenly aware that the EWA's supplies were scarce and concerned that there would be inadequate supplies avail-

FIGURE 9
**Unmet environmental water targets, 2000–2005**




Between 2002 and 2004, the EWA and the CVPIA have been underendowed, on average, by 436,000 acre-feet. CVPIA supplies began diminishing after the Interior Department's 2003 Decision (already in place in 2002), which offered far less protection than the previous policy. The EWA, which began in 2001, has never acquired the operational assets that were assumed in the CALFED Plan and its purchased assets dropped significantly in 2004 due to funding limitations. Current trends indicate that neither the EWA nor the CVPIA supplies are likely to be available in 2005 and beyond, as intended in the CALFED Plan, unless significant changes are made. Without adequate and reliable CVPIA and EWA supplies, it is unclear whether the EWA's role as an insurance policy protecting water contractors from the Endangered Species Act can or should continue.

Source: California Department of Water Resources, U.S. Bureau of Reclamation

able later in the year, sharply reduced the amount of EWA water that would be provided to the endangered fish and did not curtail exports as much or as long as was requested.[18]

In summary, it is apparent that fishery agencies now have more than 400,000 acre-feet *less* water per year in CVPIA and EWA supplies alone, compared with the requirements of the CALFED Plan, with which to comply with ESA objectives and restore the health of the Bay-Delta ecosystem (Figure 9). The backstop for this shortfall, CALFED's Tier 3, has no assets, no plan and has been virtually ignored. And, as the health of the Bay-Delta continues to spiral downward, exports from the estuary have reached record high levels.

CHAPTER 4

# Future funding prospects are highly uncertain

Since its inception, funding for the CALFED program, and particularly the EWA, has largely relied on annual allocations from California's General Fund and financing from bond revenues. Both of these sources are quickly dwindling, contrary to the CALFED Plan's expectations that long-term funding would be available from the state and federal government. After its first year, funding for the EWA has steadily declined, hindering the ability of the account to purchase water. As sources of public funding are becoming scarce and without reliable operational assets, it is uncertain how the protections included in the EWA, as set forth in the CALFED Plan, will be assured.[19] Without a viable EWA, it is unclear whether its role as an insurance policy protecting water contractors from the Endangered Species Act can or should continue.

Given the funding uncertainty, the Bay-Delta Authority was charged with completing a ten-year finance plan in 2004 to determine how best to support CALFED in the long-term. Given the lack of available public funding, there has been a growing interest in looking to the "beneficiary pays" principle included in the CALFED Plan, which relates directly to the concept of a "user fee." Under this principle, the costs of a project are allocated to specific entities in the same proportion as the direct and indirect benefits the entity is intended to receive from the project.

The potential role of user fees and other finance strategies are currently coming into play as the CALFED program undergoes an audit to evaluate its finance strategy, program management, overall program effectiveness and governance. The review process is expected to be completed in late 2005 and will include recommendations for the future of the program. Our recommendations for providing and potentially increasing the environmental water supplies required in the CALFED plan are outlined below.

CHAPTER 5

# Opportunities for greater environmental protection

There are many opportunities to realize the environmental water assurances promised in the CALFED Plan and to extend additional protection to the Bay-Delta estuary. The CALFED Plan clearly states that the EWA should be expanded with an appropriate share of newly developed water supplies.[20] The most logical approach to meeting CALFED's objectives for improving fisheries protection is to increase the water supplies available to fish when they are at risk through flexibility in project operations. Such protections should be required as operating guidelines included in the regulatory standards to which water projects much adhere.

As actions are taken to modify and modernize water management in California, opportunities will arise for obtaining the water necessary to provide additional flexibility. Some of the most promising opportunities for additional environmental water are as follows.

## Flexibility through integration of existing projects

At a closed-door meeting in Napa in 2003, state and federal export agencies, along with their contractors, identified how integrated operation of the SWP and CVP could generate additional water supplies.[21] By integrating the conveyance-rich SWP with the storage-rich CVP, water contractors have shown that exports can be increased. These additional supplies should be provided to the environment as a first priority to ensure additional operating flexibility to mitigate the adverse effects of water project operations, rather than to the export agencies that are already enjoying historically high export levels.

## Flexibility in increased export capability

Current proposals by the federal and state water projects and their contractors to increase the capacity to export water at the Delta pumping plants have met substantial resistance, given their potential impact on the Bay-Delta and its fisheries. In the event that pumping capacity is increased, however, we recommend that the additional capacity (estimated at 200,000 acre-feet) be dedicated to improving the timing of exports in order to protect fisheries. We also recommend that the overall volume of exports should not be increased until, and unless, there is a viable long-term upward trend in estuarine health. At a minimum, imposing such a constraint would motivate the water contractors to act creatively on behalf of estuarine recovery. Even with these caveats, however, it may well not be feasible to combine even higher levels of pumping with strong estuarine recovery programs, no matter how much flexibility is given to the operators in timing exports.

## Increase usable storage in San Luis Reservoir

The CVP and SWP share San Luis Reservoir, a 2 million acre-foot storage facility located south of the Delta along the federal and state aqueducts. San Luis is the primary reservoir for storing EWA supplies, but the EWA has only junior rights in the reservoir and its supplies can "spill" when the CVP and SWP fill their shares of the reservoir. Due to poorly located outlets, San Luis Reservoir's current storage capacity is not fully usable without rendering the Santa Clara Valley Water District

(SCVWD) unable to access its supplies. Solving this "San Luis Reservoir Low Point problem" by physically modifying the reservoir would provide SCVWD with both improved water quality and year-round access to the CVP while creating another 200,000 acre-feet of additional active storage. The CVP and SWP have not, as of today, allocated this storage to a specific purpose. This additional capacity should be dedicated to the EWA to enhance the environment and provide additional protection without affecting water contractors. If, on the other hand, the additional storage is dedicated to increased water supply, it may increase exports by 200,000 acre-feet annually without mitigation and thereby exacerbate environmental problems in the Delta.

## Restoring the CVPIA's commitments to fisheries protection and restoration

There are several opportunities to attain greater protection using the environmental water provided to the Central Valley and Bay-Delta by the CVPIA. The Interior Department should:

- Revise and greatly expand the use of "reoperation" pursuant to Section 3406(b)(1)(B).[22] Perhaps the single most useful application of the reoperation criteria is clarifying that B1 reoperation can be used to allow reduced late summer reservoir releases to compensate for increased springtime releases to aid outmigration, without additional charges to the B2 account.[23]
- Formally implement the May 2003 ruling of the Court of Appeals for the Ninth District regarding the "Primary Purpose" of B2. As a result, the WQCP would still be fully applied but significant portions of the B2 supply would in all years be dedicated to providing for the spawning and outmigration of salmon and steelhead. The WQCP would still be fully implemented. In 2004, the Interior Department did dedicate an additional 166,000 acre-feet to comply with obligations under the WQCP, but has shown no indication of how, or when, it will establish an official policy consistent with the court's ruling.
- Develop a policy to facilitate the authorized "banking" of B2 water (Section 3408(d)). Currently, the B2 account is in a "use it or lose it" situation, in which at the end of the water year (September 30) any remaining B2 water is eliminated. In the 13 years since the CVPIA became law, the U.S. Department of the Interior has made no serious attempt to implement the CVPIA's authorization of banking.

## Implementing CALFED's EWP and Section B3 of the CVPIA

CALFED's Environmental Water Program and Section B3 of the CVPIA are tools created to purchase water to enhance instream flows on upstream tributaries. To date, however, neither tool has lived up to its potential largely due to a lack of dedicated funding. A serious commitment is needed to fully fund and implement these tools, which could result in improvements to both upstream and Delta environmental conditions.

## Retiring drainage-impaired land in the San Joaquin Valley

The U.S. Bureau of Reclamation is currently reviewing alternatives to provide drainage service to dispose of salt-laden agricultural run-off on the west side of the San Joaquin Valley. The environmentally preferred alternative in the draft Environmental Impact Statement

involves the retirement of lands impaired by drainage which has left the soil saline and unproductive. A significant portion of the water saved as a result of land retirement should be dedicated to the environment to fulfill the assurances in the CALFED Plan.

## Implementing user fees

The CALFED Plan included several commitments to user fees and to the beneficiary pays principle. In particular, it promised the creation of the Ecosystem Restoration Program, financed partially by user fees in the amount of $35 million per year. Revenues from such a water use fee (as opposed to the reallocation of existing user fees such as those in the CVP Restoration Fund, as has been proposed by some water users) could help assure that sufficient funds are available for additional operational flexibility and could be less subject to significant shortfalls than would be the case where reliance is placed on state and federal general funds.

A water use fee would also provide water contractors with significant incentives to manage their own supplies in the most efficient manner. If the fee is high enough, water contractors might find that rather than export additional water, they might better develop their own supplies or improve efficiency in their water use.

CHAPTER 6

# Conclusion

State and federal projects are exporting record volumes of fresh water from the Bay-Delta while the Delta's fisheries and food web are severely distressed. Stakeholders have made great efforts over the years to forge creative solutions to meet a variety of program objectives, including Bay-Delta protection, but they have not been fully implemented. This report illustrates that while the environmental water supplies set forth in the CALFED Plan have not been provided, a number of opportunities exist to find the water needed to revive the Bay-Delta.

Debate will continue not only on how to balance the competing needs of environmental and developed water, but also how and when environmental water might best be applied. Research is needed to investigate the connection of introduced species, chemical contaminants and other factors to recent fishery declines. Regardless, the health of the San Francisco Bay-Delta estuary depends on a reliable set of environmental safeguards, including dependable water supplies. The EWA and CVPIA supplies that have been lost should be replaced, and potentially expanded, as soon as possible.

Any plan to sustain the estuary must include a methodology for using environmental water, assurances that water will be provided and consequences for non-compliance. It is necessary that fishery interests have a strong hand in the operation of the water projects that control the flows into and out of the Delta. Over the last five years, the failure to implement the protective operating criteria outlined in the CALFED Plan has been unacceptable. It is time for government agencies, water contractors and the interested public to implement a sustainable plan to guarantee the long-term health of the San Francisco Bay-Delta estuary.

# Notes

[1] Abundance of Delta smelt and other estuarine species are estimated by a population index that is determined by the results of the "fall mid-water trawl," conducted monthly September through December at locations throughout the estuary.

[2] Interagency Ecological Program Workplan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary, 2005.

[3] The CALFED Plan was formally released as a "Programmatic Record of Decision," pursuant to state and federal environmental laws on August 28, 2000.

[4] Tier 3 was intended to be a set of actions that would be available if the EWA did not have sufficient assets to accomplish its objectives. Despite the erosion of Tier 2, Tier 3 assets have never been provided nor is there a plan in place to do so.

[5] The CVPIA also addresses pricing policies, contract renewal, water marketing and water conservation issues. All of these elements have been subject to at least some degree of controversy and have faced difficulties in their implementation.

[6] Anadromous fish live in the ocean but return to freshwater to breed. Most of the focus of the AFRP has been on the four runs of salmon native to the Central Valley: winter run, spring run, fall run and late-fall run. The AFRP lists as a primary purpose the doubling of the natural production of anadromous fish (an objective not met by the 2002 target date).

[7] Thoroughly addressing the use of Section B3 of the CVPIA is beyond the scope of this report. To date, the use of this tool has been limited.

[8] The EPA has no authority to directly affect water rights under the Clean Water Act but the practical consequence of requiring salinity reduction in the estuary is that outflows would need to be increased.

[9] Other "local" water projects, in both the Sacramento and San Joaquin basins, have negotiated for the sale of water, both as transfers to other agencies or for environmental protection, but have not been required to make any uncompensated contributions. For example, a group of water agencies have formed the San Joaquin River Group Authority to provide additional spring flows at Vernalis to assist with outmigration of salmon.

[10] X2 is the location, measured in kilometers from the Golden Gate Bridge, where average daily salinity is 2 parts per thousand. The scientific underpinnings of the X2 standard were established in a series of workshops. See "Managing Freshwater Discharge to the San Francisco Bay/Sacramento-San Joaquin Delta: The Scientific Basis for the Estuarine Standard," San Francisco Estuary Project, 1993, J.R. Schubel et al.

[11] The Vernalis Adaptive Management Plan (VAMP) is an experiment to determine the extent to which flows and exports impact San Joaquin River juvenile salmon survival as they outmigrate. The purpose of VAMP is to support the outmigration of San Joaquin River salmon and reduce exports at the federal and state pumps between April 15 and May 15 (or when San Joaquin smolts tend to be outmigrating). Challenges to VAMP that point out its inadequacies in meeting the salmon doubling objective on the San Joaquin River have not been squarely addressed by the SWRCB.

[12] The CVPIA states that the AFRP's primary purpose is to double populations of anadromous fish, leaving water quality objectives in the Bay-Delta and Endangered Species Act compliance as secondary purposes. The Court of Appeals later ruled that the Interior Department did in fact need to apply the CVPIA's primary purpose of giving anadromous fish first priority. The Interior Department has issued no ruling clarifying its adherence to the ruling, but did dedicate additional supplies to its WQCP obligations beyond the B2 account in 2004.

[13] EWA data was provided by the Department of Water Resources. CVPIA data was provided by the U.S. Bureau of Reclamation. Environmental Defense applied Interior's 1999 Decision to the Bureau's data for 2002–2004.

[14] Review of the 2003–04 Environmental Water Account (EWA). Submitted by the 2004 EWA Technical Review Panel, January 17, 2005.

[15] A target of $50 million annually for the EWA was initially proposed in "California's Water Future: A Framework for Action", released in June 2000 shortly before the CALFED Plan. This original estimate assumed that more than 80% of purchased supplies would be acquired south-of-Delta. Water managers have found it to be more cost-effective to purchase water north-of-Delta and move it south through the Delta export pumps when monitoring indicates that relatively few fish will be entrained in the Delta export pumps.

[16] Availability of willing sellers has not been the problem. Acquiring funding to pay the sellers has been the challenge.

[17] Whether bond funds were intended to be spent on annual operations, rather than on long-term or permanent capital improvements or acquisitions is an issue that has not explicitly been addressed in CALFED's decision-making.

[18] Summary of interagency "Data Assessment Team" conference call February 1, 2005.

[19] The acquisition of assets and assurance of reliable supplies need not be identical to those defined in CALFED's EWA. The key is to assure a sustainable and reliable supply of environmental water for the purpose of flexible and prescriptive actions for optimum environmental protection.

[20] CALFED Programmatic Record of Decision, August 28, 2000, p. 57.

[21] Formally titled "Draft Proposition Concerning CVP/SWP Integrated Operations", the Napa Proposition was made available to the public in August 2003.

[22] The California Resources Agency tends to agree with this suggestion. See January 15, 2005 letter from California's Department of Water Resources and Department of Fish and Game to the U.S. Bureau of Reclamation and the U.S. Fish & Wildlife Service regarding "Integration of Central Valley Project Improvement Act Actions with the Environmental Water Account."

[23] This amount of reoperation often approaches 195,000 acre-feet since the CVP no longer makes releases to support its own exports through "D1485 Wheeling" at the state's pumps in late summer. The CVP's export reductions at that time are properly considered to be charges to the B2 account.

e

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Attachment 14

NRDC
THE EARTH'S BEST DEFENSE

NATURAL RESOURCES DEFENSE COUNCIL

December 10, 2007

Ms. Sammie Cervantes
Bureau of Reclamation
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scervantes@mp.usbr.gov

**VIA ELECTRONIC AND U.S. MAIL**

Re: Comments on the Draft Supplemental EIS/EIR for Extending the Environmental Water Account and OCAP Consultations

Dear Ms. Cervantes:

We are writing on behalf of the Natural Resources Defense Council (NRDC) and its more than 120,000 members in California with regard to the draft supplemental EIS/EIR ("DSEIS/EIR") for the Environmental Water Account ("EWA"). The DSEIS/EIR proposes to extend the existing EWA program, which is currently set to expire at the end of 2007, for another four years, through 2011. The U.S. Bureau of Reclamation and the California Department of Water Resources, the co-lead agencies for the DSEIS/EIR, propose to take this action without providing any analysis of how the EWA has functioned since its inception in 2001 or whether the EWA has succeeded in achieving its stated fish protection purposes. In fact, the EWA has *not* functioned as envisioned and, by placing artificial restraints on the amount of water ostensibly available for fish protection, has contributed to the *decline* of imperiled fish in the Delta, most of which are in worse condition today than they were in 2001. For these reasons, we urge the agencies to discontinue the failed experiment of the EWA, and to devote the taxpayer resources currently dedicated to the EWA to actions that could provide a real benefit to imperiled fish.

In previous biological opinions on the joint operations of the Central Valley Project and State Water Project (i.e., the "Operating Criteria and Plan" or "OCAP"), the agencies have considered the EWA a central feature to mitigate the harmful impacts of the projects on listed fish. The Bureau has reinitiated consultation on those OCAP biological opinions, and those reconsultations are ongoing. Apparently, the agencies have not yet defined the "project" for this reconsultation and it is unclear whether the agencies are contemplating including the EWA in the new project description. Because the EWA has failed to function as a fish protective measure and should not be considered an effective mitigation or conservation tool in the new biological opinions, we seek consideration of these comments in those ongoing consultations as well. Likewise, we request that this information be incorporated, by DWR and DFG, into efforts to comply with the requirements of CESA.

## I. THE EWA HAS NOT FUNCTIONED AS ENVISIONED

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There is no doubt that in past years the water promised for fish protection through both the Environmental Water Account and the CVPIA (b)(2) account has been significantly less than what was promised in the CALFED ROD. *Finding the Water: New Water Supply Opportunities to Revive the San Francisco Bay-Delta*, Environmental Defense, 2005 (appended as Exhibit 1). From 2001-2004, the EWA provided only 29% on average of the expected 195,000 acre-feet of operational assets. *Id.* at 12-13. Collectively, the EWA and b(2) have contributed as much as 500,000 acre-feet *less* water per year towards fish protection and restoration than anticipated in the CALFED ROD. These shortfalls have occurred while exports from the Delta have reached record high levels and the ecosystem has continued spiraling downward. Clearly, the EWA experiment has not performed as planned.

The failure of the EWA to function as envisioned is epitomized in the failure of the agencies to invoke Tier 3 this year – the intended backstop for any shortfall in EWA assets. EWA Tier 3 was supposed to ensure that if EWA was underfunded or failed to perform as anticipated (both of which have happened), sufficient water would be provided to ensure no jeopardy to listed fish. As explained in the Tier 3 Protocol, a copy of which is appended hereto as Exhibit 2:

> As part of the MSCS Conservation Agreement and the FWS and NMFS biological opinions, the CALFED agencies have provided a commitment, *subject to specified conditions and legal requirements,* that for the first four years of Stage 1, there will be no reductions, beyond existing regulatory levels, in CVP or SWP Delta exports resulting from measures to protect fish under FESA and CESA. *This commitment is based on the availability of three tiers of assets:*
>
> ...
>
> Tier 3 is based upon the commitment and ability of the CALFED Agencies to make additional water available should it be needed.
>
> ...
>
> Tier 3 is a fail-safe device, intended to be used only when Tier 1 and Tier 2 are insufficient to avoid jeopardy to the continued existence of an endangered or threatened species.
>
> ...
>
> The State and Federal Projects will be responsible for making preparations for the activation of Tier 3.

(Emphasis added). This language makes clear that the assurances provided under CALFED, and the ESA and CESA compliance of the EWA, were dependent upon the existence and availability of these Tier 3 assets.

Unfortunately, when the time came to call upon this Tier 3 "fail-safe", the agencies failed to trigger it, ensuring that listed species rather than water users would suffer the consequences of the failure of the EWA to live up to its stated purpose. There can be no question that Tier 1 and Tier 2 have been and are insufficient to avoid jeopardy to the threatened delta smelt. A federal court held in May of this year that the "delta smelt is indisputably in jeopardy as to its survival and recovery." *NRDC v. Kempthorne*, Order on Summary Judgment at 119 (May 25, 2007). This finding echoes the findings of several expert fisheries biologists, including staff of many

state and federal agencies. *See, e.g.*, DSWG Briefing Statement (May 15, 2007) ("the species has become critically imperiled and an emergency response is warranted") (attached hereto as Exhibit 3); Statement Presented by Ryan Broddrick, Director, CDFG, to House Subcommittee on Water and Power (July 2, 2007) ("it is DFG's position that actions must be taken to protect as many individual smelt as can be through manipulation of the water projects. Each reproducing organism is important to the survival of the species.") (appended hereto as Exhibit 4). Despite these findings and the continued take of large numbers of delta smelt at the Project pumps this past summer, *see* delta smelt May, June and July take tables (appended hereto as Exhibit 5), the Project agencies obstinately refused to invoke Tier 3.

Inexplicably, the DSEIS/EIR makes no mention of this breakdown of the EWA's "fail-safe", nor does it describe or analyze the historical shortfalls of the EWA or the program's failure to function as envisioned. These shortcomings are far more relevant to the foreseeable impacts of extending the program than any of the purely hypothetical modeled impacts contained in the DSEIS/EIR. The DSEIS/EIR must be revised to address these issues. Further, these historical realities belie the statement in DSEIS/EIR that "[i]f pumping would be likely to put at risk the continued existence of a species listed as endangered or threatened under the Endangered Species Act (ESA), the Project Agencies would curtail pumping even if purchases already totaled 600,000 acre-feet and all assets were used." DSEIS/EIR at ES-5. This is precisely the situation that presented itself to the Project Agencies this summer, and the agencies failed to curtail pumping once EWA assets were depleted even though continued pumping threatened the continued existence of the delta smelt.

Moreover, the DSEIS/EIR seeks to utilize the ESA/CESA process for coverage of the EWA initially established in the CALFED ROD, without addressing any of these fundamental failures of the process to operate as envisioned and which were essential to the CALFED analysis. *See generally* DSEIS/EIR Appendix C.[1] For example, Tier 3 no longer exists as a viable "fail-safe device." Yet, the CALFED assurances were explicitly "based on the availability of three tiers of assets." Tier 3 Protocol. The DSEIS/EIR makes passing reference to this change, obliquely noting that "[b]ased on current circumstances, these three tiers are no longer an accurate way to describe EWA assets." DSEIS/EIR at 2-4. But the document fails to acknowledge the implications of omitting this critical "fail-safe device" or to describe the replacement structure of the EWA going forward.

In short, the DSEIS/EIR fails to adequately describe the project to decisionmakers and the public or to disclose the environmental impacts associated with the policy choice of extending the EWA. The document should be revised to correct these shortcomings. We believe that an accurate description and assessment of the EWA will demonstrate that the program should not be extended.

---

[1] The DSEIS/EIR also fails entirely to discuss the state court decision finding that DWR lacks the necessary CESA coverage for operation of the SWP, which also likely impacts the CESA analysis in Appendix C. It is unclear, for example, how EWA assets pumped through the SWP facilities at Clifton Court forebay and Banks pumping plant have CESA take authority when the court found that the SWP lacked any take authority for its pumping operations. The DSEIS/EIR must be revised to address this issue.

## II. THE EWA HAS LIMITED, RATHER THAN EXPANDED, THE AMOUNT OF WATER AVAILABLE FOR IMPERILED FISH

Since shortly after the first EWA ROD was signed in 2004, the program has been used as an excuse by the agencies to deny needed water to imperiled fish rather than to help protect and recover imperiled fish. For example, in February 2005, when delta smelt populations were at then-record low levels, fishery biologists recommended that exports be curtailed to reduce entrainment. However, because EWA supplies were scarce, project managers did not curtail exports as much or as long as was requested. *Compare* "Data Assessment Team" call notes (Feb. 1, 2005) (recommending combined exports be reduced to 1500 cfs for one week) (appended hereto as Exhibit 6, without attachments) *with* CVO smelt report (February 2005) (showing much higher combined export levels) (appended as Exhibit 7). Hundreds of delta smelt were taken at the pumps as a result. *Id.* The lawful and proper course of action would have been for the agencies to fully implement the recommended action, and then use non-EWA project water to meet fish needs later in the year if EWA supplies ran short. Instead, the program has been implemented to turn this requirement on its head, and to short fish without any consideration given to imposing uncompensated reductions on project contractors and other water users.

Unfortunately, the agencies have continued this pattern of using limited EWA assets to deny needed fish protection actions. In 2006, as the delta smelt continued its unparalleled decline in abundance, the Delta Smelt Working Group ("DSWG") evaluated a range of protective actions that could be taken to lessen the impacts of water project operations. One action that was evaluated was to address fall (September-December) Delta salinity levels by making releases from upstream reservoirs to increase Delta outflows. The discussions and analyses of this proposed action are reported in DSWG notes for July 10 (see also the notes from August 21, and Sept 26 (appended hereto as Exhibits 8). The DSWG determined that the fall action had a high likelihood of being successfully implemented and that the scientific basis for the action was supported by statistically significant correlations.

Ultimately, the fall action was not taken because it was determined that "the amounts of water needed to demonstrably improve fall habitat quantity/quality [were] unavailable". Based on analyses provided by DWR, the amount of water necessary for maintaining net Delta outflows at 7000 cfs for the September-December period would range from only 170-433 TAF. DSWG notes (Aug. 21, 2006). As a result of not taking this action, Delta outflows steadily declined, falling below 6000 cfs in October, and salinity levels shifted upstream of 80 km, the critical threshold identified by the DSWG for delta smelt habitat quality and subsequent abundance. Delta smelt abundance plummeted to a new record low the following year, indicating that the fisheries agencies were not sufficiently addressing adverse habitat conditions in the Delta and other stressors to ensure the delta smelt's survival and recovery.

Perceived unavailability of water assets was also the reason behind the DSWG rejecting a protective action in winter 2006 intended to set net flows in Old and Middle Rivers to zero cfs to better protect pre-spawning adults. Low San Joaquin River inflows and negative flows on Old and Middle Rivers, concurrent with high export rates, are likely creating hydrodynamic conditions that draw greater numbers of fish to the pumps and correspond to significantly higher

salvage rates. Protection of these biologically valuable spawning adult fish is essential for recovery and sustainability of this at-risk species. Despite the expected benefit of taking this action, it was rejected because "DWR staff have derived estimates of the water costs of the potential actions in the Resources Agency POD Action Matrix and found that the proposed winter action could consume all available environmental water, leaving no assets for spring actions for larvae or juveniles." DSWG notes (Dec. 11, 2006) (appended as Exhibit 9); *see also* DSWG notes (Oct. 10, 2006) ("The Working Group notes that some of the weaknesses of the DFG plan included the potential to exhaust all EWA and B2 assets in winter, leaving nothing in reserve for spring actions") (appended as Exhibit 10).

More recently, NMFS' biologists testified against taking actions to protect delta smelt based on a similar misperception that the total amount of water available to protect imperiled salmonids was limited to a pot of "environmental water" defined by EWA and b(2) assets, and that water used to protect smelt would necessarily deplete the amount of water available to protect salmon. *See* Declaration of Bruce Oppenheim in *NRDC v. Kempthorne* ((June 15, 2007) (appended as Exhibit 11). For example, Mr. Oppenheim explained that "the use of environmental water after VAMP on the San Joaquin River may have consequences later in the year on the Sacramento River." *Id.* at 3. This statement is only true if there is a limited pot of "environmental water" available to meet all fisheries needs – a position that is contrary to numerous requirements of state and federal law.

All of these decisions are based on the incorrect assumption that the amount of water available to protect listed fish species is limited to the assets of the EWA, CVPIA b(2), and other sources of water "dedicated" to the environment. The Bureau has perpetuated this fallacy, asserting that it must meet the needs of CVP contractors before meeting the needs of listed fish species. *See* Declaration of Ronald Milligan in *NRDC v. Kempthorne* (June 21, 2007) ("Reclamation operates New Melones to meet ... project needs of the East Side Division CVP contractors" which leaves "no additional water available for out of basin releases from New Melones Reservoir" even if needed to prevent jeopardy to listed delta smelt) (appended as Exhibit 12); *see also see also* Transcript of Hearing re Interim Remedies Day 7, *NRDC v. Kempthorne*, Testimony of Ronald Milligan at 1553-54 (Aug. 31, 2007) (explaining that the WOMT rejected some recommendations of the DSWG because of concerns regarding "the ability for the EWA to function in a manner that it could, in essence, pay back the projects for curtailments without impacting operations in the long term sense or allocations to contractors") (appended as Exhibit 13). Similarly, DWR has asserted that it has no additional water available for fish protection, while simultaneously making hundreds of thousands of acre-feet of surplus "Article 21" and "turnback pool" water available to water users and contractors.

This presumed EWA limitation on the amount of water available to protect fish is simply not correct. Numerous courts have made it abundantly clear that the Bureau and DWR must provide sufficient water to protect and recover listed fish species, whether it exceeds the amount of the water the agencies may have earmarked for that purpose or not. *See, e.g., NRDC v. Kempthorne*, Order on Summary Judgment at 61 (May 25, 2007) ("The EWA is simply a means by which the SWP and CVP can obtain water by purchasing it from willing sellers. ...If money is unavailable to fund the EWA, Defendants are nonetheless required to prevent smelt take from exceeding permissible take limits. ... [I]f all else fails, [additional] assets may be brought to bear, which

include 'additional purchased or operational assets, funding to secure additional assets if needed, or project water if funding or assets are unavailable.'") (emphasis in original).

The agencies have turned the EWA on its head and, instead of using it to supplement the resources needed *and required* for fish protection, have used it as an excuse to short the environment and avoid committing those mandatory resources. Unless the agencies make very clear that limited EWA assets cannot be used as a reason not to take an action that would help protect or restore imperiled fish, it should be discontinued.

## III. THE ANALYSIS FAILS TO DEMONSTRATE THAT THE EWA HELPS PROTECT AT-RISK FISH SPECIES AND CONTRIBUTE TO THEIR RECOVERY

In addition to the problems discussed above, the DSEIS/EIR fails to provide adequate support for its conclusion that extending the EWA would benefit fish protection and restoration.

First, the document recognizes in several places that a pumping "window" during which EWA assets may be pumped out of the Delta without increasing adverse impacts to listed fish no longer exists. The document explains that "[t]he EWA protects fish at the pumps by reducing pumping when it would help at-risk fish species, then transferring EWA assets across the Delta at other times to repay CVP and SWP users for water lost during pump reductions." DSEIS/EIR at 2-15. The DSEIS/EIR asserts that EWA assets should be used to reduce export pumping to protect fish from the months of December through July. DSEIS/EIR at 2-10 to 2-11. This proposal allows exports to increase to allow delivery of EWA water during the months of August through November. But several imperiled species are vulnerable to take at the pumps during this late summer/fall period. *See id.* at 2-13, 4-15. Moreover, the document notes that the alarming and continuing decline in four pelagic organisms in the Delta have corresponded to a period of "increased exports during June through December." DSEIS/EIR at 4-11. In addition, recent studies have indicated that decreased Delta inflows in late fall and winter may result in reductions in fall habitat quality and eastward movement of X2, which may result in adverse impacts to fish. DSEIS/EIR at 4-13. Thus, it is unclear when a safe pumping window exists for EWA to increase Delta exports. Instead, it is likely that an extended EWA would simply help sustain the current record high levels of exports pumped out of the Delta – export levels that have corresponded to many of the declining fish populations in the Delta. *See, e.g., id.* at B-3 to B-4 (Banks pumping would increase in July, August, and September to convey EWA assets).

Second, the DSEIS/EIR assumes with no support that "[w]hile the fish actions in … revised biological opinions [that are currently being developed for project operations] are unknown, they would likely be less than with the EWA program." DSEIS/EIR at ES-4. This statement reflects a fundamental misunderstanding of the nature of ESA and CESA requirements, which *mandate* that project operations cause no jeopardy to the existence *or recovery* of listed species, cause no adverse modification of critical habitat for survival *or recovery* of listed species, and that the impacts of project take be minimized and fully mitigated. In addition, Section 7 also imposes an affirmative obligation on federal agencies to "utilize their authorities in furtherance of the purposes of this chapter by carrying out programs for the conservation of endangered species and threatened species listed" under the Act. 16 U.S.C. § 1536(a)(1). A program of "conservation" is one that brings the species to the point of recovery and delisting. *Id.* § 1532(3). In short, the

project agencies are obligated to protect, recover and conserve listed species, whether or not the EWA is in place.

Third, the DSEIS/EIR explicitly bases its analysis of fish actions on the invalidated, reinitiated, and discredited OCAP biological opinions, claiming that it "would be speculative to assume that the fish actions in the BO will be the same as those described by Judge Wanger because the BO will be based on a comprehensive review of all available information and science." DSEIS/EIR at 1-6. In reality, Judge Wanger's decision is based on a more comprehensive and current review of the science regarding the delta smelt than the invalidated BO, which failed even to acknowledge the precipitous decline of the delta smelt in recent years. In addition, the OCAP BO on listed salmonids has been discredited by more than three independent science reviews, including a CALFED review panel, which concluded that the BO was not based on the best available science. The DSEIS/EIR's reliance on the fish actions encompassed in these discredited BOs for the basis of its analysis lacks a reasonable basis.

Fourth, the Bureau has reinitiated consultation with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service on the OCAP. That consultation is ongoing. Until the Bureau meets the requirements of ESA §7 and, among other things, obtains a valid biological opinion at the conclusion of consultation, the ESA § 7(d) prohibition on making any irreversible and irretrievable commitment of resources applies to the Bureau's actions. Regional Director Kirk Rodgers has correctly recognized that reauthorization of the EWA during the pendency of the OCAP consultations would be a violation of §7(d), and has (twice) sworn to a federal court that such authorization would not occur before completion of the new BOs. *See* Declaration of Kirk Rodgers (Oct. 18, 2006), Declaration of Kirk Rodgers (July 9, 2007) (appended hereto as Exhibit 14). Reauthorization of the EWA as proposed in the DSEIS/EIR runs afoul of the 7(d) prohibition and contradicts Mr. Rodgers sworn statements in the pending OCAP lawsuits.

Finally, the DSEIS/EIR concludes that continuation of the EWA "would have a less than significant impact on X2 location during June through December." DSEIS/EIR at ES-9. However, as the document recognizes, emerging science indicates that moving X2 westward of its recent historic location in the fall could have a significant beneficial impact on listed species and their habitat. By reducing outflow in the fall, EWA could have a significantly detrimental impact on the ability of agencies to meet this new threshold.

## IV. THE ANALYSIS FAILS TO EVALUATE THE EWA'S FAILURE TO ASSIST IN ECOSYTEM RESTORATION BEYOND ESA/CESA COMPLIANCE

To date, as discussed above, the EWA has primarily, even exclusively, been operated to limit protective ESA/CESA actions. However, the failure of the EWA extends even farther. The EWA was intended to "provide water for the protection and recovery of fish." CALFED Programmatic ROD at 54. Note that these benefits are not restricted to listed species. The ROD also states that the EWA will "acquire water for ecosystem and species recovery needs." CALFED ROD NCCP Determination at 21. Thus, the EWA was intended as a tool to provide restoration benefits beyond the requirements of ESA/CESA for listed species. These benefits were an important part of the Ecosystem Restoration Program and were the justification for

public funding for the EWA. The document does not analyze the failure of the EWA to provide these anticipated benefits.

Indeed, far from facilitating improved ecosystem health, by limiting ESA/CESA actions and by increasing diversions during the August to November period, the EWA has damaged ecosystem health. This failure is indicated by the fact that non-listed species, such as threadfin shad, are showing the same decline affecting listed species such as the delta smelt and that the Pelagic Organism Decline process has identified "water project operations" as a potential cause of the decline of Delta fishes. *See* Interagency Ecological Program 2006-2007 Work Plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary (January 12, 2007) at 4 (appended hereto as Exhibit 15). The document does include one, inadequate mention of these impacts, by concluding that "(t)he entrainment indices for threadfin shad and American shad would be increase." DEIS/EIR at 4-36. Clearly, the EWA has undermined, rather than facilitated, the CALFED ecosystem restoration goal.

The document must be revised to fully and adequately evaluate the failure of the EWA to contribute to fisheries and ecosystem restoration beyond the requirements of ESA/CESA.

## V. THE ANALYSIS FAILS TO EVALUATE THE EWA'S FUTURE USEFULNESS TO FACILITATE "REAL TIME" MANAGEMENT

The EWA was also intended to provide "real time diversion management" of Delta flows and the CVP and SWP Delta pumps. CALFED ROD NCCP Determination at 29. Such real time management assumes that the EWA has enough flexibility to modify Delta flows and the management of the projects beyond the relatively fixed prescriptive requirements of ESA/CESA compliance. The document fails to analyze the extent to which the EWA will provide such flexibility to achieve additional ecosystem or protective measures. Unless the management priorities or assets of the EWA are changed dramatically (a change that this document does not anticipate) it appears unlikely that the EWA will have much, if any, flexibility to provide additional protective measures. To the contrary, to the extent that the EWA provides real time management, this flexibility is designed to increase pumping, potentially causing additional impacts to the ecosystem, and designed solely to provide additional water supplies for South of Delta CVP and SWP contractors.

## VI. THE FAILURE TO ANALYZE PAST PERFORMACE UNDERMINES A FUNDAMENTAL PURPOSE OF THE EWA -- TO FAILITATE ADAPTIVE MANAGEMENT

The CALFED ROD was designed with science-based adaptive management as a "central feature." CALFED Programmatic ROD at 4. This document repeats this assertion that "(a)daptive management is a key component of the EWA," and that "(a)daptive management provides a process to change fish actions or asset acquisitions." DSEIS/EIR at page 2-24. The careful evaluation of the past performance of management tools is the defining feature of adaptive management, in order to allow improved, adaptive future management. Indeed, the ROD explicitly commits CALFED agencies to "assess the success of EWA operations." CALFED ROD EWA Operating Principles Agreement at 4. Without such analysis, agencies

cannot "adapt" the management of the program in a manner that builds on past successes and responds to failures. The analysis of past performance of the EWA as an adaptive management tool is critical to the central purpose of this document – extending the EWA into the future. Such analysis is also important to agencies, such as the Delta Vision Task Force, the Bay-Delta Conservation Plan process, the Department of Fish and Game, NOAA Fisheries and the Fish and Wildlife Service, which may consider the merits of incorporating the EWA into future management for the Delta. Finally, such analysis is essential to the legislature and the Administration as they consider the justification for public funding for the EWA. An analysis of the past performance of the EWA will reveal that there is no justification for such continued public funding. As discussed above, the document fails to analyze past performance, a failure that cuts to the core of the purpose of the EWA as an adaptive management tool. The document must be revised to fully and accurately analyze the effectiveness of the EWA as an adaptive management tool.

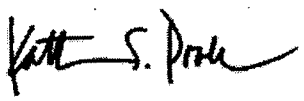
## VII. THE DOCUMENT FAILS TO DESCRIBE ACCURATELY THE PROJECT PURPOSE

As discussed above, the document does not adequately analyze the EWA's failure to engage in real time management and adaptive management, to ensure ESA/CESA compliance and to contribute to broader ecosystem restoration. The document also does not include any meaningful provisions to address these failures. The document, however, largely maintains the old, inaccurate description of the purpose of the EWA. DSEIS/EIR at page 2-3. Thus, the document fails to adequately describe the purpose of the project. At the moment, the actual purpose of the EWA appears to be to limit protective actions under ESA and CESA, and to provide additional water supplies to south of Delta water contractors. The document should be revised to include an accurate description of the project.

## VIII. CONCLUSION

In light of these many shortcomings in the operation of the EWA and the analysis of the DSEIS/EIR, we urge you to reject the proposal to extend the program beyond the end of 2007. In the alternative, we urge you to withdraw this document and issue a new, adequate draft that addresses the concerns outlined above.

Sincerely,



Katherine S. Poole
Senior Attorney

Barry Nelson
Senior Policy Analyst

Cc: Cay Goude, USFWS
Maria Rea, NMFS
John McCammon, DFG
Lester Snow, DWR

# Attachment 14-A

# EXHIBIT 2

Provisional
Updated April 26, 2004

# TIER 3 PROTOCOL

## Interrelationship of Tier 2 and Tier 3

Tier 3 is referenced on pages 57 and 58 of the CALFED August 2000 Record of Decision (ROD) in the following context:

> ***ESA Commitments***
>
> *As part of the MSCS Conservation Agreement and the FWS and NMFS biological opinions, the CALFED Agencies have provided a commitment, subject to specified conditions and legal requirements, that for the first four years of Stage 1, there will be no reductions, beyond existing regulatory levels, in CVP or SWP Delta exports resulting from measures to protect fish under FESA and CESA. This commitment is based on the availability of three tiers of assets:*
>
> ***Tier 1*** *is baseline water, provided by existing regulation and operational flexibility as described above. The regulatory baseline consists of the biological opinions on winter-run salmon and delta smelt, 1995 Delta Water Quality Control Plan, and 800 TAF of CVP Yield pursuant to CVPIA Section 3406(b)(2).*
>
> ***Tier 2*** *consists of the assets in the EWA combined with the benefits of the ERP and is an insurance mechanism that will allow water to be provided for fish when needed without reducing deliveries to water users. (These assets are shown in the table on page 58 of the ROD). Tier 1 and Tier 2 are, in effect, a water budget for the environment and will be used to avoid the need for Tier 3 assets as described below.*
>
> ***Tier 3*** *is based upon the commitment and ability of the CALFED Agencies to make additional water available should it be needed. It is unlikely that assets beyond those in Tier 1 and Tier 2 will be needed to meet ESA requirements. However, if further assets are needed in specific circumstances, the third tier will be provided. In considering the need for Tier 3 assets, the fishery agencies will consider the views of an independent science panel. Although the CALFED Agencies do not anticipate needing access to Tier 3 of water assets, the CALFED Agencies will prepare an implementation strategy for Tier 3 by August 2001, establishing a timely scientific panel process and identifying tools and funding should implementation of Tier 3 prove necessary.*

Provisional
Updated April 26, 2004

**Tier 3 Protocols**

1. **Tier 3 is not an operational reserve for Tier 2.** The CALFED Agencies agree that Tier 3 actions are separate from EWA and that the EWA should not rely upon the existence of Tier 3 assets in its planning or operations. Tier 3 is a fail-safe device, intended to be used only when Tier 1 and Tier 2 are insufficient to avoid jeopardy to the continued existence of an endangered or threatened species.

2. Tier 3 assets will be used when: (1) EWA assets are exhausted (see Item 3); and (2) the Management Agencies determine that jeopardy due to project operations will occur unless additional measures are taken (see Item 4 below).

3. EWA assets are defined as exhausted when all real assets have been used and the limit on borrowing has been reached. The real assets include (1) the purchased assets that are being acquired for 2004; and (2) any operational assets that have been accrued or can reasonably be acquired in the near future. For 2004, the initial limit on borrowing has been established as 100 TAF. This amount represents the amount of water that could be extracted from groundwater in any single year. Additional borrowing may be developed through the year, but would be on a case-by-case basis.

4. The appropriate Management Agencies will make the determination that a species is near jeopardy if project operations are not modified. The Management Agencies will request and consider the views of an independent science panel. At a minimum, this science panel will consist of the two EWA science advisors who are expected to respond within 48 hours. If sufficient time is available, additional independent scientists may be consulted. The Management Agencies have the discretion to take action while awaiting feedback from the science panel.

5. **Tier 3 assets will be used to the extent available to compensate the Projects and water users for impacts to their water supply from actions taken to avoid jeopardy.** If all Tier 3 assets are used, and additional actions are needed to avoid jeopardy, ESA consultation regarding project operations will be re-initiated. The biological opinion on re-initiation will include reasonable and prudent alternatives necessary to avoid jeopardy. Actions to avoid jeopardy will not be limited by the "no harm" principle (i.e.: there is no commitment that all water supply losses can be fully mitigated).

6. **The State and Federal Projects will be responsible for making preparations for the activation of Tier 3.** DWR and USBR are responsible for making preparations for the activation of Tier 3, just as they are responsible for acquiring EWA assets. Such preparations could include the acquisition or identification of water purchase options that could be converted easily into water. The cost of exercising the options would be paid by the Tier 3 fund. The Project Agencies should work cooperatively with the EWAT and other CALFED-related water purchase programs in developing a Tier 3 purchase plan.

# Attachment 14-B

# EXHIBIT 3

## Briefing Statement

From: Delta Smelt Working Group

To: Water Operations Management Team

Date: May 15, 2007

Re: Recommendations for Spring Action

Problem:
To date, the 2007 20-mm Survey for juvenile delta smelt has collected record low numbers of juvenile delta smelt. After the fifth of eight surveys, only 25 individuals have been collected, about 7.7 percent of the 326 taken to this point in 2006, and only 7.1% of the 2000-2006 average of 353. The DSWG has reviewed the progression of catches that typically occur during the course of the 20-mm Survey to evaluate the chance that there will be an upswing in the number of larvae collected later this year that will bring 2007 catches more in line with previous years. The group considers such an increase in catches to be possible but unlikely.

The likelihood of a very low outcome creates a very high degree of concern for the Delta Smelt Working Group. Water temperatures in the Delta have risen above the range wherein the majority of delta smelt spawning occurs, meaning that very little additional spawning is likely to take place this year. Further, the most recent 20-mm Survey results shows that delta smelt are distributed in the central Delta, increasing the risk of entrainment. In fact, the first salvage of delta smelt juveniles were observed at the Federal water export facility on May 11. For an annual species such as delta smelt, failure to recruit a new year-class is an urgent indicator that the species has become critically imperiled and an emergency response is warranted.

Recommendation:
The goal is no further entrainment of delta smelt. To achieve this, the Projects should modify flows to achieve a non-negative daily net flow (meaning daily net flow should not be southward) in Old and Middle River. This should be implemented as soon as possible and continue until southern Delta water temperatures reach $25^0$C, the lab-lethal limit.

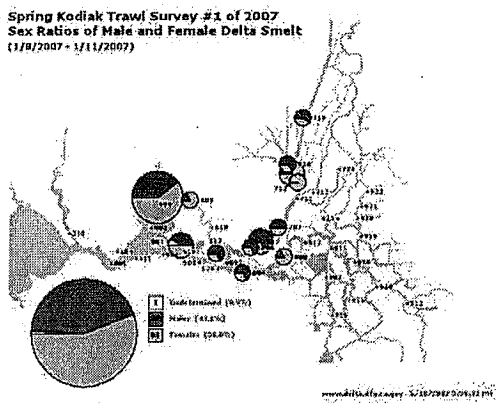
Uncertainties:
(1) The DSWG recognizes that water project operations are not the only forces driving down delta smelt numbers. Although we are confident the proposed action will reduce entrainment, it is uncertain whether it will substantially increase the percentage of this year's recruit class that survives to reproduce next winter. (2) The group also recognizes that it may not be possible, given flows and constraints on Project pumping, to achieve a zero net flow in Old and Middle River. (3) Given that delta smelt densities appear to be near the lower limit at which the 20-mm Survey may reliably detect them, our ability to accurately assess distribution of delta smelt larvae and to evaluate the efficacy of the recommended action is likely to be very low. (4) There is no prescriptive recommendation regarding the Head of Old River Barrier (HORB); however, it is possible that the HORB's influence on OMR flow may be significant. Removing the barrier may therefore be a possible management tool to achieve the Working Group's recommendation.

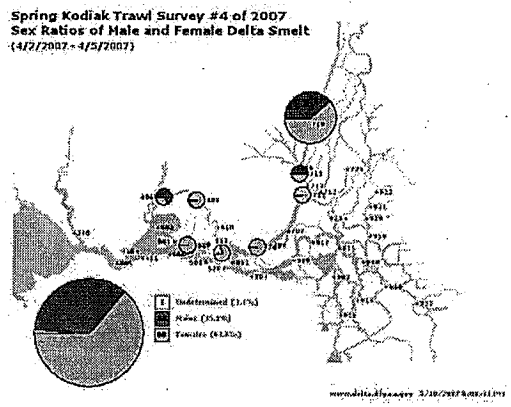
Management Implications:
The water cost of the recommended operational change is presently unknown, but may be significant.

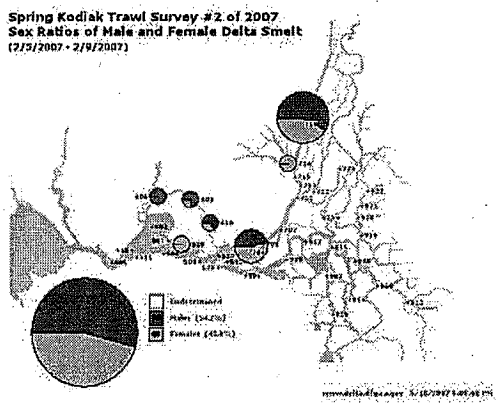
Attachments:

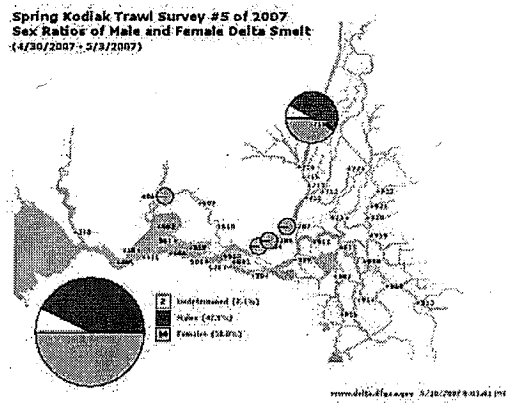
1. Summary of Spring Kodiak Trawl survey for pre-spawning adult delta smelt
2. Summary of 20-mm Trawl survey for juvenile delta smelt
3. Frequency Distribution for 20-mm Survey
4. Frequency Distributions of Delta Smelt in the 20-mm Survey, 1995-2007
5. Frequency Distribution of Delta Smelt in the 20-mm Survey, 1995-2007. Equal scale on x-axis.

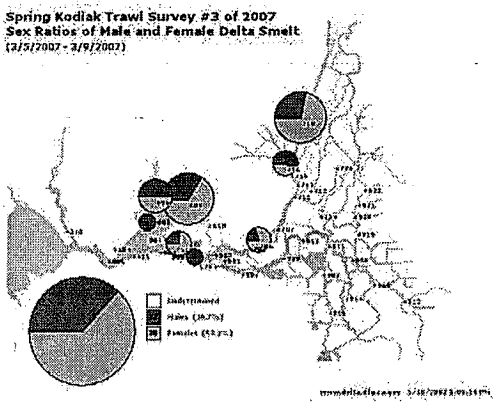
**Attachment 1.** Summary of Spring Kodiak Trawl survey for pre-spawning adult delta smelt, 2007. Note that the distribution of adult delta smelt appears to be favorable, with regard to risk of entrainment. Overall numbers collected were low relative to previous years.



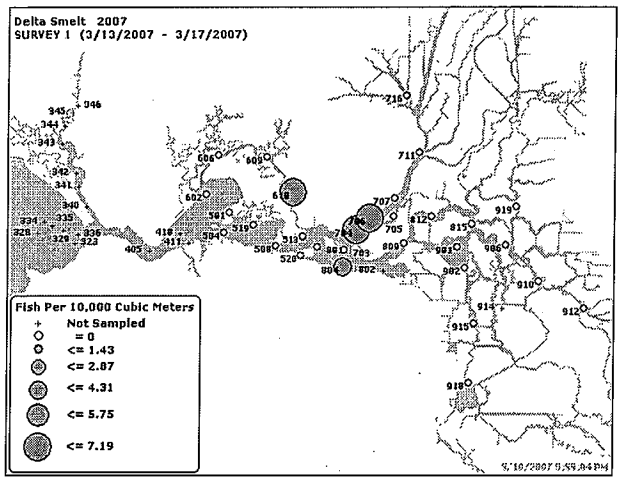



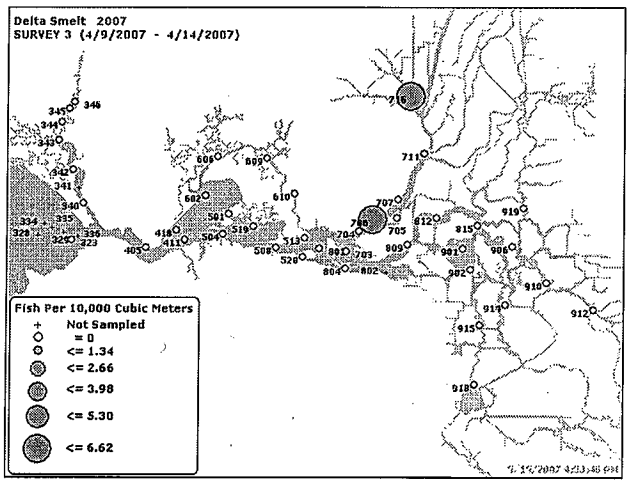



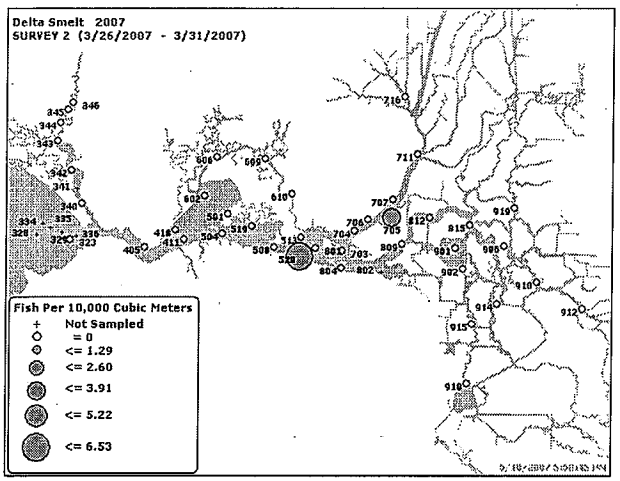

Comparison of SKT surveys, by year

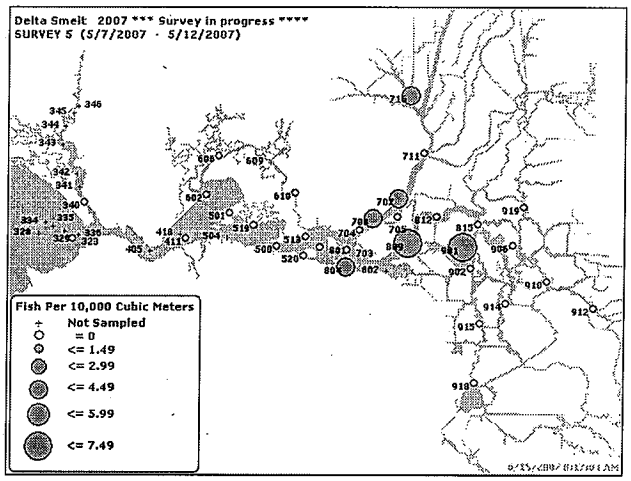
| | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 |
|---|---|---|---|---|---|---|
| 1 | 109 | 42 | 220 | 380 | 232 | 261 |
| 2 | 107 | 84 | 218 | 300 | 373 | 392 |
| 3 | 60 | 70 | 27 | 196 | 43 | 238 |
| 4 | 94 | 77 | 28 | 62 | 33 | - |
| 5 | 28 | 14 | - | 13 | - | - |
| N | 398 | 287 | 493 | 951 | 681 | 891 |

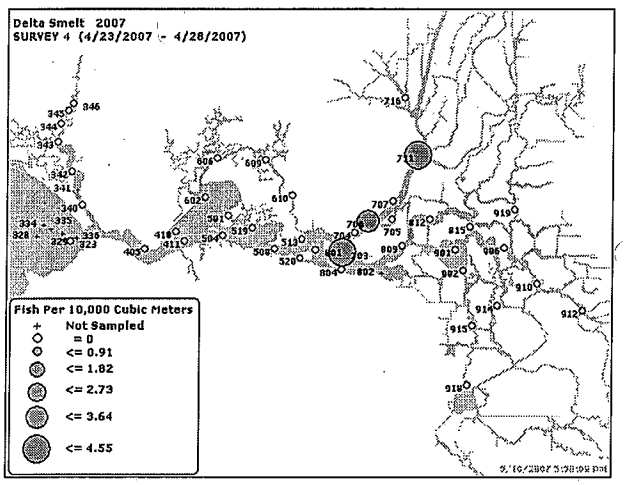
**Attachment 2.** Summary of 20-mm Trawl survey for juvenile delta smelt, 2007. Early distributions of juveniles were similar to adult distribution as indicated by SKT results, but the latest survey results are less favorable. Overall numbers collected were extremely low relative to previous years.



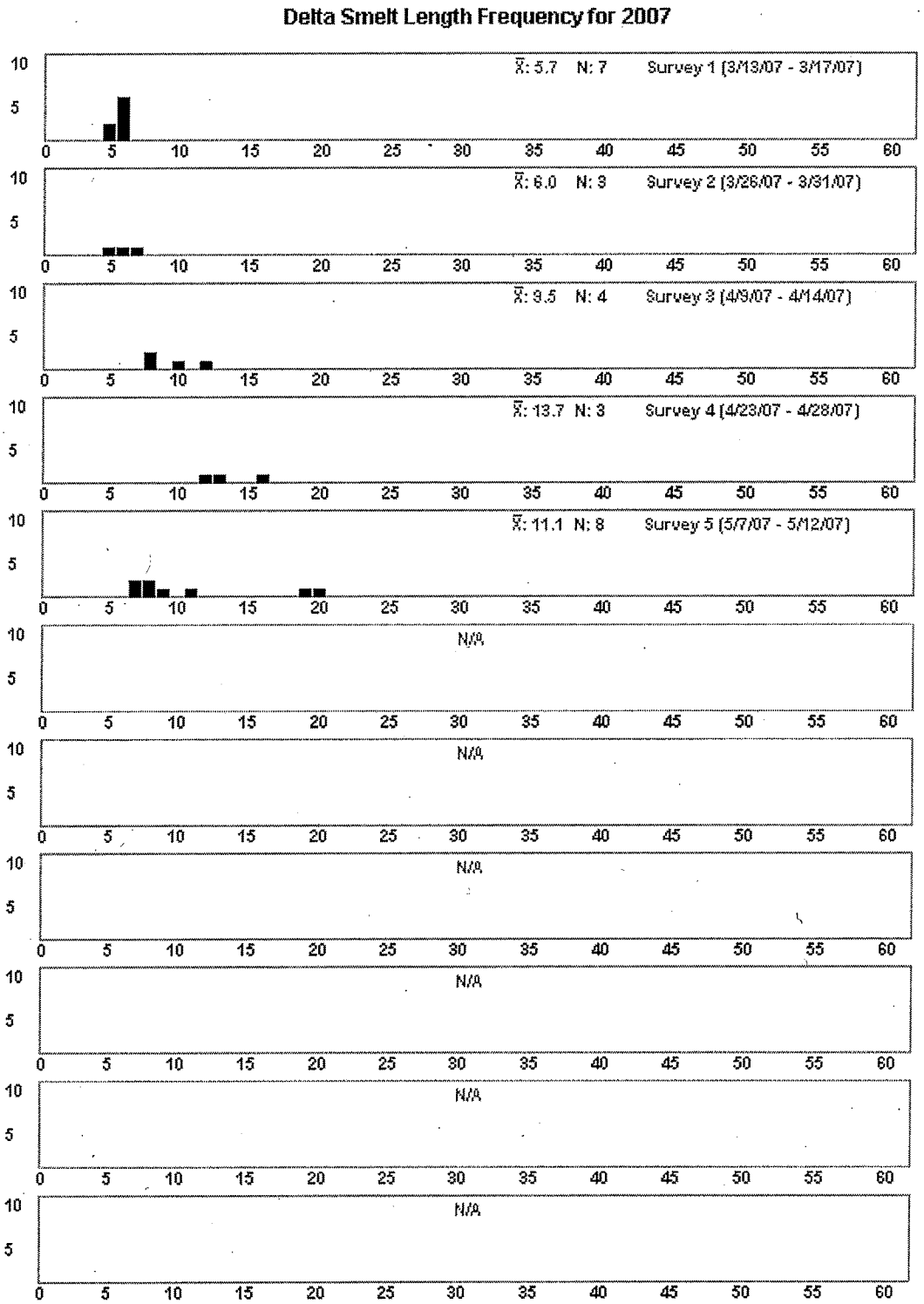



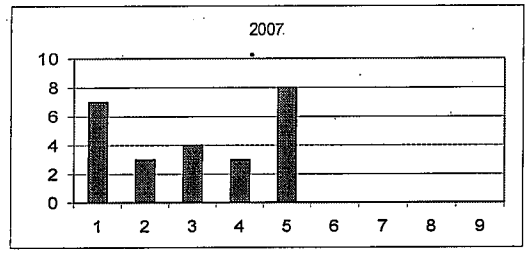



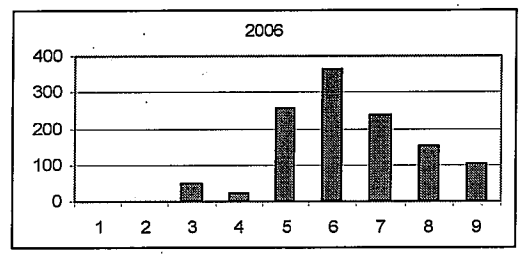



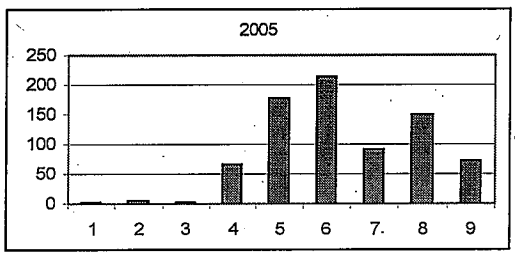
**Attachment 3.** Frequency Distribution of Catch, 20-mm Survey, 2007.

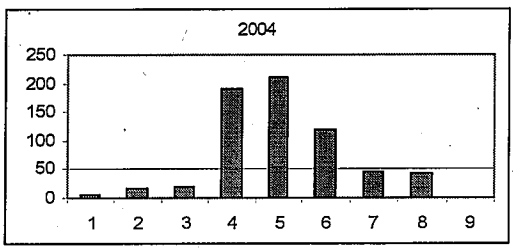


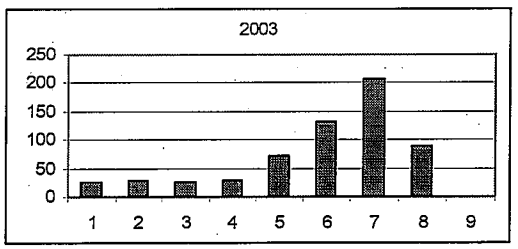
**Attachment 4.** Frequency Distributions of Delta Smelt in the 20-mm Survey, 1995-2007.

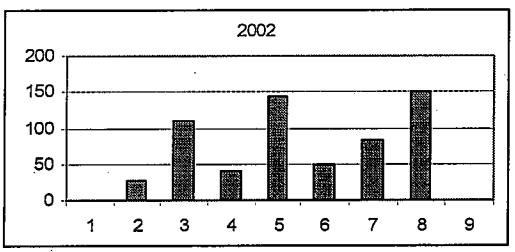


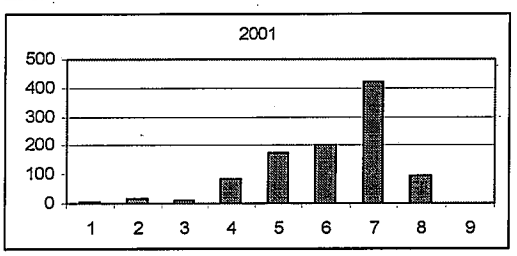



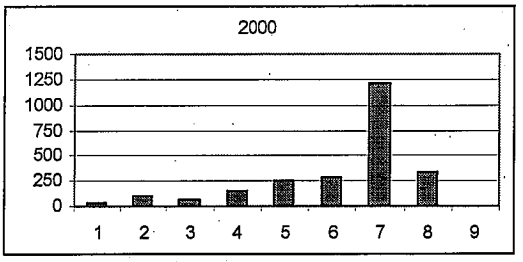



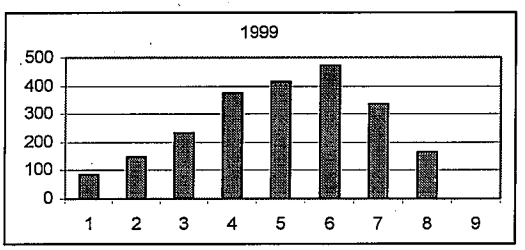



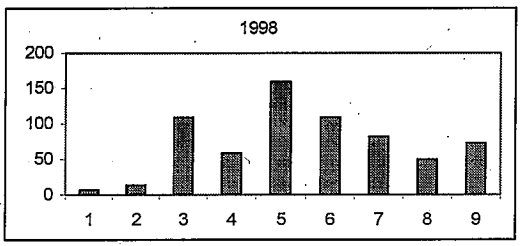



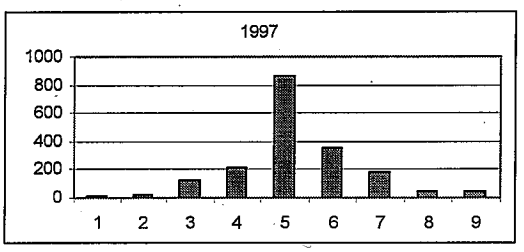



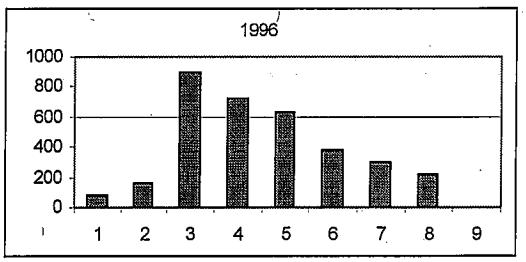



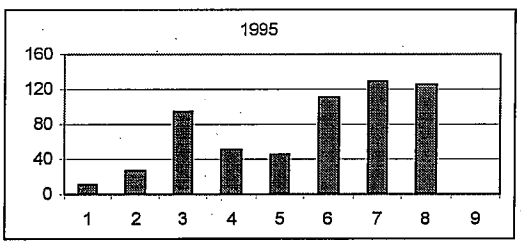



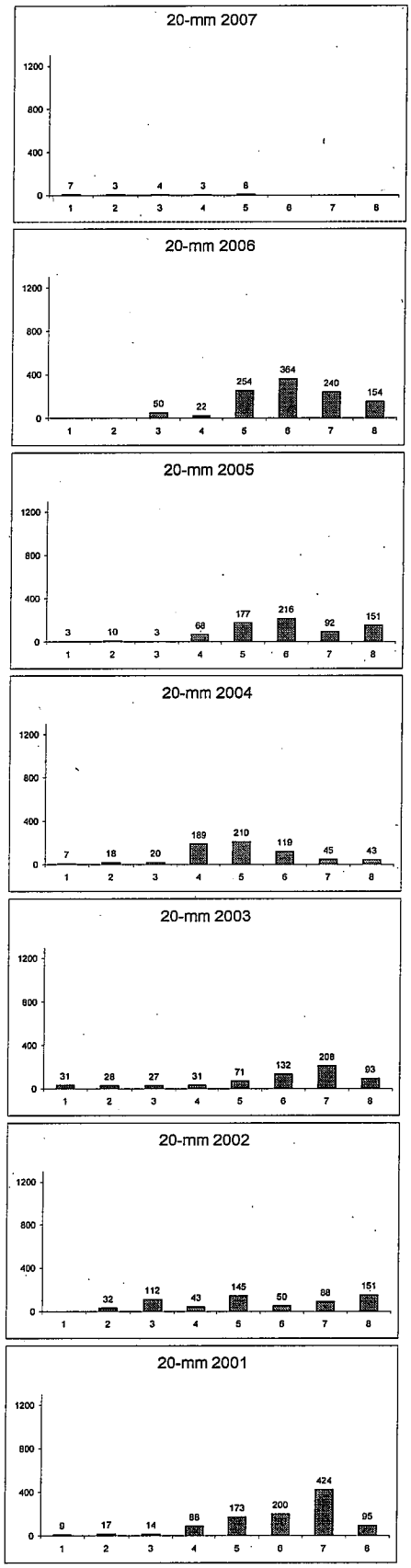



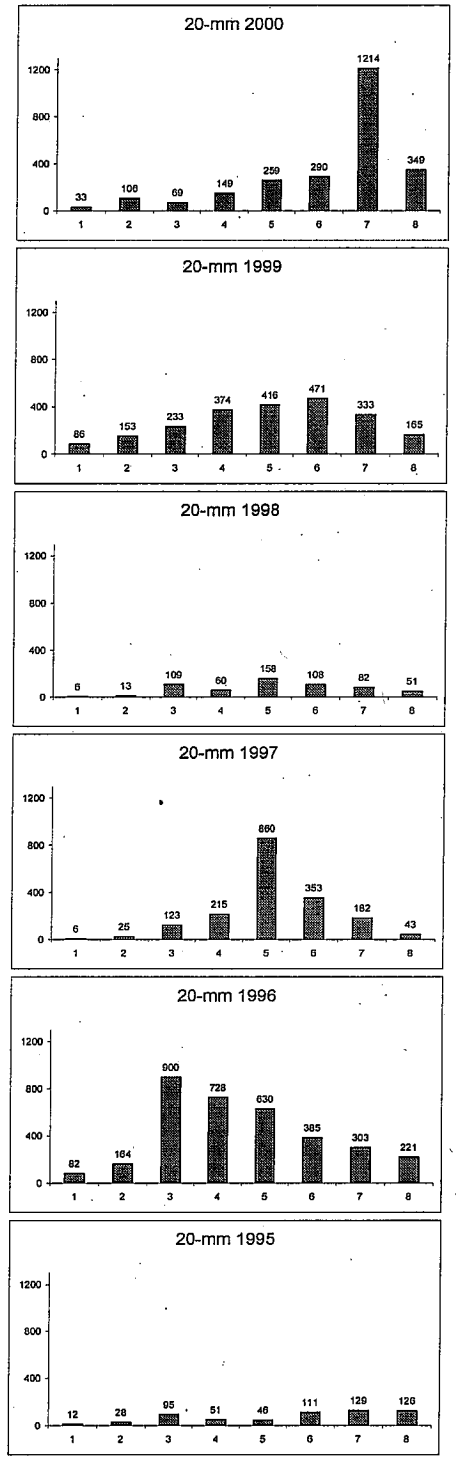




The vertical axis is number collected in the CDFG 20-mm Survey. The horizontal axis is survey number.

**Attachment 5.** Frequency Distribution of Delta Smelt in the CDFG 20-mm Survey, 1995 to 2007. Equal scale on x-axis.




The vertical axis is number collected in the CDFG 20-mm Survey. The horizontal axis is survey number.

# Attachment 14-C

# EXHIBIT 4

**Statement Presented by**
**Ryan Broddrick**
**Director, California Department of Fish and Game**
**To**
**U.S. House of Representatives, Committee on Natural Resources**
**Subcommittee on Water and Power**
**Oversight Hearing on "Extinction is not a Sustainable Water Policy: The Bay Delta Crisis and the Implications for California Water Management"**
**July 2, 2007**
**Vallejo City Council Chambers, Vallejo, California**

I appreciate the opportunity to provide input to this Subcommittee on the important and urgent matter of declining fishery resources in the San Francisco Bay/San Joaquin Delta Estuary. Of particular concern to us is the recent serious and unexpected decline (approximately 90%) in young Delta smelt produced this season. As alarming as the reduced numbers are, this decline is part of a more generally observed decline in other important fish and aquatic resources in the estuary. Anadromous fish (steelhead and salmon), sport fish (striped bass), other native fishes, and some important fish food organisms (invertebrates) of the Delta are in serious trouble and have been receiving our attention in planning and regulatory activities. The California Department of Fish and Game is actively involved in efforts to determine causes, implement response measures within our authorities, and develop a long-term strategy for Delta sustainability. The Federal Government's involvement is crucial to developing a comprehensive and long term solution to fix the "broken Delta".

There are many causes for the fish and invertebrate declines and our understanding of these causes is limited. Our cooperative efforts to determine the causes of the decline have pointed towards invasive species, toxics, predation and water diversions as having primary roles in the declining health of the Delta. We continue to monitor, evaluate and explore these issues in order to make further scientifically justified determinations as to the role of each factor and how issues may be addressed in order to ensure future Delta health.

Governor Schwarzenegger has initiated a comprehensive Delta Vision effort to rethink what the Delta should look like in the future. A Blue Ribbon task force has begun meetings designed to lead towards recommendations for actions by the legislature and Governor. In addition, many state and federal agencies, along with a growing number of environmental groups, signed a formal Planning Agreement in September 2006 and are developing the Bay Delta Conservation Plan (BDCP) for at-risk fish species under the provisions of the State Natural Community Conservation Planning Act (NCCPA) and Section 10 of the federal Endangered Species Act. These efforts will provide a framework, plan, and commitment for future action.

## Background- The Pelagic Organism Decline

The Interagency Ecological Program (IEP), a multi-agency state and federal group, has monitored and studied biological and hydrological resources in the Estuary for almost 40 years. The data set generated by the IEP is one of the most complete data sets documenting relationships between fish and aquatic resources and water development projects in the world. The information developed during this time has provided the foundation for our understanding of the ecological implications of water resources management in this system. In early 2005, scientists from our IEP first observed serious declines in Delta smelt and certain other pelagic fish species (see Figure 1). In response, directors of the state and federal water and fish agencies directed approximately $2.5 million for establishment of a Pelagic Organism Decline (POD) team to investigate the reasons for the decline. The POD team developed a study plan that identified three likely hypotheses responsible for the observed declines and embarked upon an aggressive and comprehensive effort to identify and address all likely causes for this decline. The three most likely stressors, possibly acting in concert, were identified as water diversions, invasive species/food chain changes, and toxics.

One year after the POD studies began, the team presented their first Synthesis Report and developed two scenarios among other possible causes: winter exports and bad environmental conditions in Suisun Bay. Data from the State and Federal water project facilities showed that water exports had increased during the winter months of November - March during the years of the pelagic organism decline (See Figure 2). Salvage data also showed that increased numbers of those fish showing the decline (Delta smelt, threadfin shad, striped bass and longfin smelt- see Figures 3 and 4) had also been taken in increasing numbers during that time. The second most likely hypothesis called the "Bad Suisun Bay Hypothesis", suggested that conditions in the Suisun Bay area, a prime nursery area for young fish, had changed in some way to reduce its capability to sustain fish populations. The report suggested that some undefined combination of food production, invertebrate grazing rates, salinity regime changes, and introduced exotic species may be responsible for the declines. At that time toxics were not implicated as a major influence in the observed declines.

During the end of the first year of the POD investigations, researchers were beginning to develop information that could be helpful in understanding the declines and also for managing conditions to potentially reduce impacts. In the fall of 2006, the CALFED Program hosted the Science Conference and two significant findings were presented. First, a University of California researcher (Dr. Bill Bennett) suggested that the delta smelt females that reproduced early in the spawning season seemed to be most important in contributing to the next generation of smelt. This became known as the "Big Momma Hypothesis". This suggested that more attention needed to be paid to water management earlier in the year than had been done heretofore. The second finding, by a USGS researcher (Dr. Pete Smith) suggested that there was a significant relationship between flows moving UPSTREAM toward the state and federal pumping plants in Old and Middle Rivers and fish caught later in the trawls surveys. In other words when flows upstream were greater, the negative impacts on smelt populations were greater. Both of

these findings would play a significant role in how fish and water agencies would manage the water projects in 2007.

During the 2006 water year, conditions were better and greater outflows moved the smelt further downstream in the estuary and away from the influence of the pumps. The abundance indices reflected a positive response and the numbers of Delta smelt increased slightly from the previous year. Things were looking slightly better for smelt.

## 2007 Activities

**Water Diversions**-Armed with new scientific findings, the fishery and water management agencies began to manage the water projects to facilitate protection of delta smelt and other aquatic resources in the estuary. The life cycle of Delta smelt (Figure5) was constantly considered in this process. Clearly water diversions from the Delta can cause direct and indirect mortality of Delta smelt and other aquatic organisms. For this reason, the Delta diversions of the State Water Project (SWP) and the Central Valley Project (CVP) are some of the most carefully regulated and monitored water diversions anywhere. Early in January 2007, a team of agency managers (Water Operations Management Team- WOMT) began operation of the state and federal pumping plants by trying to reduce upstream flows in Old and Middle rivers so that the important early reproducing smelt ("Big Mommas") would not be drawn upstream toward the pumps and potentially removed from the estuary. Pumping rates were reduced using assets from the Environmental Water Account (EWA). By late May, the WOMT used over 300 thousand acre feet of Environmental Water Account water to implement fish protection actions, primarily protecting the spawning females during January, February and March. During winter and early spring the projects reduced net upstream flow in Old and Middle Rivers and no delta smelt were observed at the State Water Project and only a few at the Federal facility. Conditions looked good and the new management tools (reducing Old and Middle river flows to protect spawning females) seemed to be providing the desired impact avoidance. Field surveys showed the spawning smelt still securely distributed in Cache Slough and the Sacramento Ship Channel- out of the influence of the pumping plants.

On about May 15, field surveys (the 20 mm survey) carried out to monitor the relative abundance of juvenile smelt produced in the system produced alarming results. Numbers of young smelt were about 90 % below our previous year's estimates (See Figure 6). More alarming was the fact that the young smelt were located in an area influenced by the pumps- the lower San Joaquin River! The WOMT immediately took action and reduced pumping significantly at the pumping plants. Diversions from the SWP facilities were reduced to 350 cubic feet per second (cfs), a 90 percent reduction from customary seasonal pumping levels, as a precaution. The federal CVP reduced pumping rates to 850 cfs. Additionally, WOMT ordered the Head of Old River Barrier culverts opened and

maintained flows in the Stanislaus River so that flows would remain higher in the San Joaquin River to help keep the young smelt from the pumps.

When greater smelt take occurred at the SWP intake facility in late May, DWR and the DFG jointly announced further curtailment of SWP Delta diversions and asked for voluntary curtailments by other Delta diverters. DWR stopped SWP Delta diversions entirely on May 31, 2007 for 12 days with future protective actions continuing to be guided by the best science and adaptive management. Other water diversions from the Delta are not monitored or regulated as carefully. Nevertheless, on June 1, 2007, DFG wrote to over 300 water diverters in the Delta asking them to "voluntarily cease or substantially reduce your diversions from the south delta channels..." DFG also restricted all non-essential scientific studies and fish sampling/monitoring that may incidentally take Delta smelt. Concurrently, the CVP reduced Delta diversions to the operation of a single pump, drawing about 850 cfs. After taking no smelt for two weeks, the CVP increased pumping to 2500 cfs on June 13, 2007. Nine hours later several smelt were taken at the Federal pumps, a clear indication that young smelt were still in the south delta area and caution regarding increased pumping should be used.

On June 17, 2007, the SWP and CVP increased pumping but still far below seasonal normal rates. Agency Directors became directly involved and daily operational decisions were made to reduce take of smelt at the facilities. As smelt grew and began to move downstream out of the influence of the pumps and temperatures approached the lethal limits of young smelt, pumping rates were allowed to increase to meet demands for water use in the state. As of June 27 some young smelt continued to be taken at the SWP.

Agency biologists studying the population dynamics of smelt now believe that the abundance of smelt in the estuary has reached such a low level that numbers are now being affected by the "stock recruitment relationship". In other words, the most important factor affecting smelt numbers is the number of juveniles produced by the adult females. During other times when populations are higher, this relationship is not as significant and other factors contribute to the regulation of abundance (these are discussed below). **Therefore, it is DFG's position that actions must be taken to protect as many individual smelt as can be through manipulation of the water projects. Each reproducing organism is important to the survival of the species.**

**Invasive Species-**The San Francisco Estuary has been called the most invaded estuary on earth. Among the hundreds of introduced species, many cause competition, predation, or habitat modification that are detrimental to Delta smelt and other pelagic fishes. Collectively all of these species are profoundly affecting the ecological functioning of the estuary. For example, the Asian clam Corbula, which became established in Suisun Bay in the 1980s is a filter feeder so effective and numerous that it can filter the entire volume of Suisun Bay in less than a day. This has had a devastating effect on the primary production of Suisun Bay. Further upstream the freshwater Asiatic clam, Corbicula, can

have a similar effect. In the late 1990s a new zooplankton Limnoithona invaded the estuary. This new zooplankton may not be a good food source for many important pelagic fish like Delta smelt and has replaced the smelt's preferred food source. Limnoithona is now the most abundant zooplankton in the estuary. This shift at the base of the food web may prove to be a major factor affecting Delta smelt. The toxic blue green algae Microcystis has increased in abundance in the past several years in the interior Delta causing concerns with both fish and human toxicity although none has been documented in this system. Other introduced species such as striped bass and black bass prey upon smelt directly. The Brazilian water weed Egeria, has also proliferated in recent years. This aquatic plant not only clogs water ways for boating but slows water velocity and allows suspended sediment to settle out. It is hypothesized that increased water clarity may reduce Delta smelt feeding success and increase predation upon them. Although eradication is impossible, DWR and the Department of Boating and Waterways are partnering to implement a control program for Egeria budgeted at $3 million per year.

DFG and DWR are working aggressively to prevent new invasions. The two agencies responded swiftly when the quagga mussel Dreissena was discovered in Lake Mead and the Colorado River. If this prolific filter feeder were to invade the estuary it would likely cause further alteration in the food web. Much more effort needs to be exerted in order to deal with the problem of introduced species.

**Toxics-**Since 2005, scientists have been conducting toxicity screening of the waters in the Delta and Suisun Bay as part of the IEP Pelagic Organism Decline (POD) studies. Studies in 2005 and 2006 focused on the summer months when juvenile smelt are present in the Delta. To better characterize toxicity during the smelt spawning period, bi-weekly sampling and aquatic toxicity testing was initiated in January 2007. Preliminary evidence indicates potential toxicity in the Delta this winter and spring. The most troubling fact about these detections is that they occurred in the spawning grounds for Delta smelt this year when both adults and their young were present. Even though the number of adult Delta smelt this year was a little larger than last, the number of young smelt collected this year was about 90 percent less than last year (see above discussion). Although there is no evidence of direct toxicity to the Delta smelt, Delta toxicity could affect smelt directly or affect food availability for the species.

Researchers have initiated toxicity testing using cultured Delta smelt and are collecting samples upstream of the toxic sites in an attempt to identify the source and cause of the toxicity. The State Water Resources Control Board (State Water Board) and the Central Valley Regional Water Quality Control Board are actively evaluating all of this year's information to identify any necessary actions to prevent this type of toxic effect on endangered species from happening again next year.

Other new research provides an anecdotal suggestion that episodic toxicity could play a role in smelt survival. A study tracking tagged salmon in the south Delta collected apparent evidence in May of extensive salmon smolt mortality in a single area. This kind of event, if proven to be related to toxics, has the potential to seriously affect a species such as the Delta smelt and warrants further investigation.

The State Water Board held a workshop on June 19, 2007 to receive recommendations, and information to support these recommendations, on immediate, short term actions it should consider to slow or stop the decline of smelt and to improve fishery resources. The State Water Board is looking for information on both water quality and flow-related actions. Any increased involvement on the part of the federal government in these efforts would be welcome.

**Current Restoration Efforts**

In addition to near-real time management of the Estuary through processes discussed above, DFG is also involved in larger scale ecosystem planning to enhance the estuary. Early implementation of the Ecosystem Restoration Program (ERP) began three years prior to the signing of the CALFED ROD in August 2000 in recognition that ecological systems take time to show change. In the first nine years of implementation, ERP has made significant progress in improving the natural system. ERP has awarded more than $615 million to 493 projects. To date, 276 projects or about 56 percent have been completed. Grant recipients reported approximately $285 million in matching funds, which resulted in a combined total of about $825 million spent on habitat and species associated with the Bay-Delta and its watersheds. Many ERP actions addressed priority Multi-Species Conservation Strategy (MSCS) species listed in the milestones. Restoration planning for the Suisun Marsh through the Suisun Charter process will result in the restoration and protection of 7,000 acres of wetlands in San Pablo Bay and Suisun Marsh, exceeding the Stage 1 target for tidal marsh restoration in San Pablo Bay. Restoration of tidal action to restore brackish marsh ecosystems within the next two years on the Blacklock property and Meins Landing will aid in the recovery of several listed and special status terrestrial and aquatic species. Restoration of tidal action and associated wetlands habitat on the 1,166 acre Dutch Slough Tidal Restoration Project will improve our understanding of ecological processes and how ecosystems function at different spatial scales.

The ERP has funded 82 fish screen projects to reduce mortality of salmonids. The ERP has also implemented channel and floodplain restoration projects to improve spawning and rearing habitat for salmonids including projects on key tributaries to the Sacramento and San Joaquin rivers. Removal of impediments to fish passage on Butte Creek, Clear Creek, and other Sacramento River tributaries has contributed to the rebounding of spring-run and fall run Chinook salmon populations observed in recent years. The Battle Creek Salmon and Steelhead Restoration Project is an exceptional conservation opportunity to reestablish 42 miles of prime and uniquely reliable salmon and steelhead habitat on Battle Creek and its tributaries. Successful implementation of this project will help restore populations of winter-run Chinook salmon, spring run Chinook salmon and steelhead, all of which are in danger or threatened with extinction as defined by the federal Endangered Species Act (FESA). Battle Creek offers this unique restoration opportunity because of its geology, hydrology, habitat suitability for several anadromous species, historical water allocation, and land use compatible with a restored stream environment. Of these qualities, the area's unique hydrology is perhaps the most important Battle Creek feature supporting its restoration potential. The Lower Yuba

River Accord EIR/EIS was released for public review on June 26th. The purpose of the Yuba Accord is to resolve instream flow issues associated with the operation of the Yuba River Development Project in a way that protects and enhances lower Yuba River fisheries, maintains local water-supply reliability and protects Sacramento-San Joaquin Delta fisheries. The ERP this year also funded the Narrows 2 bypass project on the Yuba River to protect habitat for the wild salmon and steelhead on the lower Yuba River.

## Summary

This brief discussion of stressors, management actions, and organism responses is intended to convey our understanding that the pelagic organism decline, including the recent sharp drop in Delta smelt abundance, is an extremely complex phenomenon. We do not expect that the solution to such a complex problem lies in just one category of action. We will continue to be guided by the best science and adaptive management as our scientists work to understand the situation and our agencies seek solutions to Bay Delta problems both in the near-term and for the future.

Whatever actions we may take, we must include interests of all parties. As you know, there are no independent actions that can be taken in this complex system. Fishery agencies constantly balance needs of various listed species, and important non-listed species. Actions that affect the water projects also can potentially affect other users of water in the State including state and federal wildlife refuges. Before any actions are implemented careful consideration of associated fish and wildlife impacts is needed.

DFG is supportive of the federal government taking actions necessary to protect and restore the pelagic species and in particular the Delta smelt. We will work with you and others to accomplish this important result.

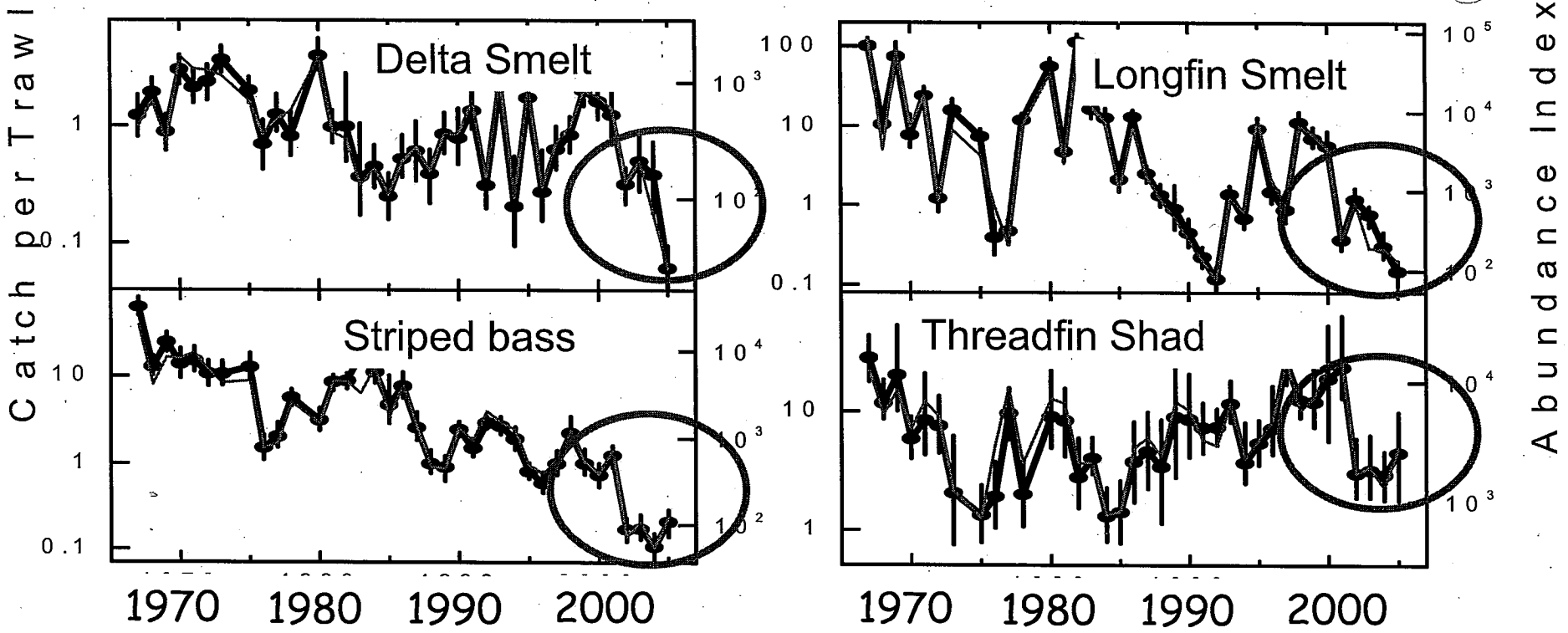



Figure 1. Annual abundance trends of four POD fishes based on Fall Midwater Trawl Survey data. Annual mean catch per trawl (black line) and annual abundance index (red line) are depicted.

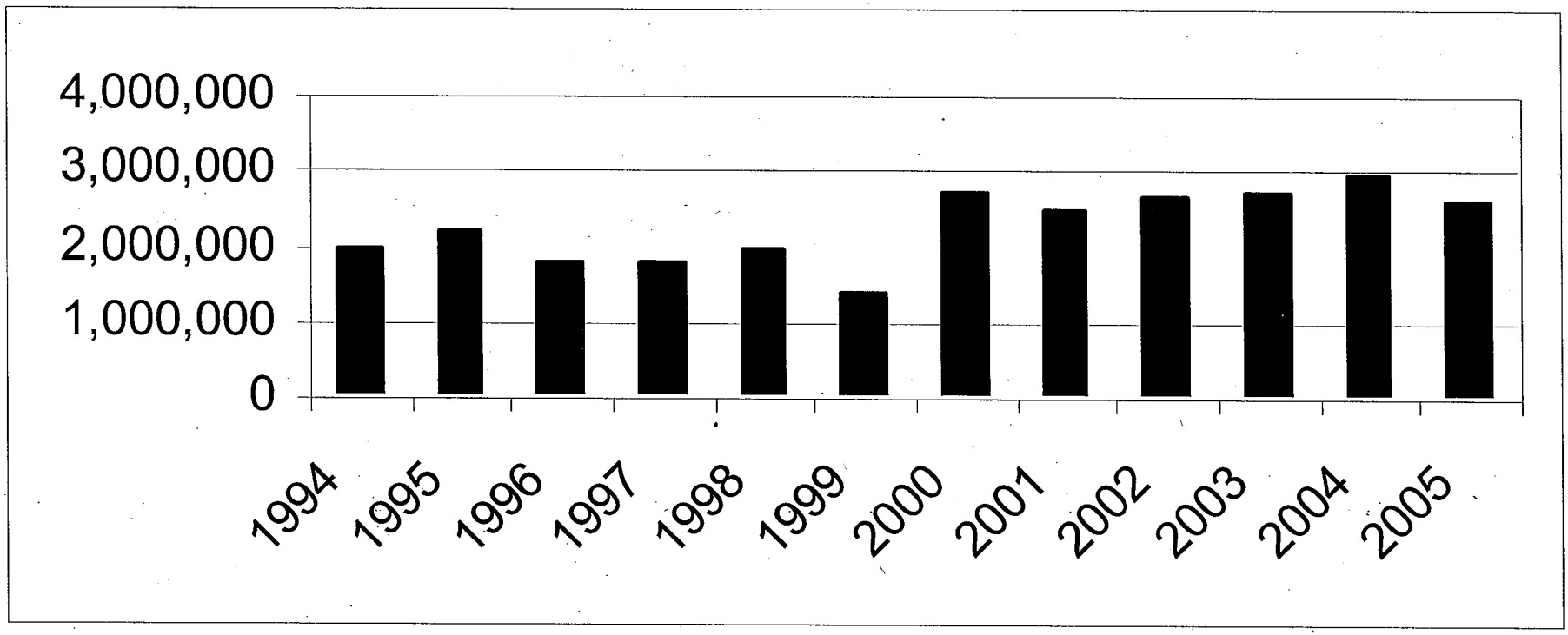



Figure 2. Total combined State Water Project and Central Valley Water Project winter exports (sum November through March) in acre feet plotted on year beginning in January.

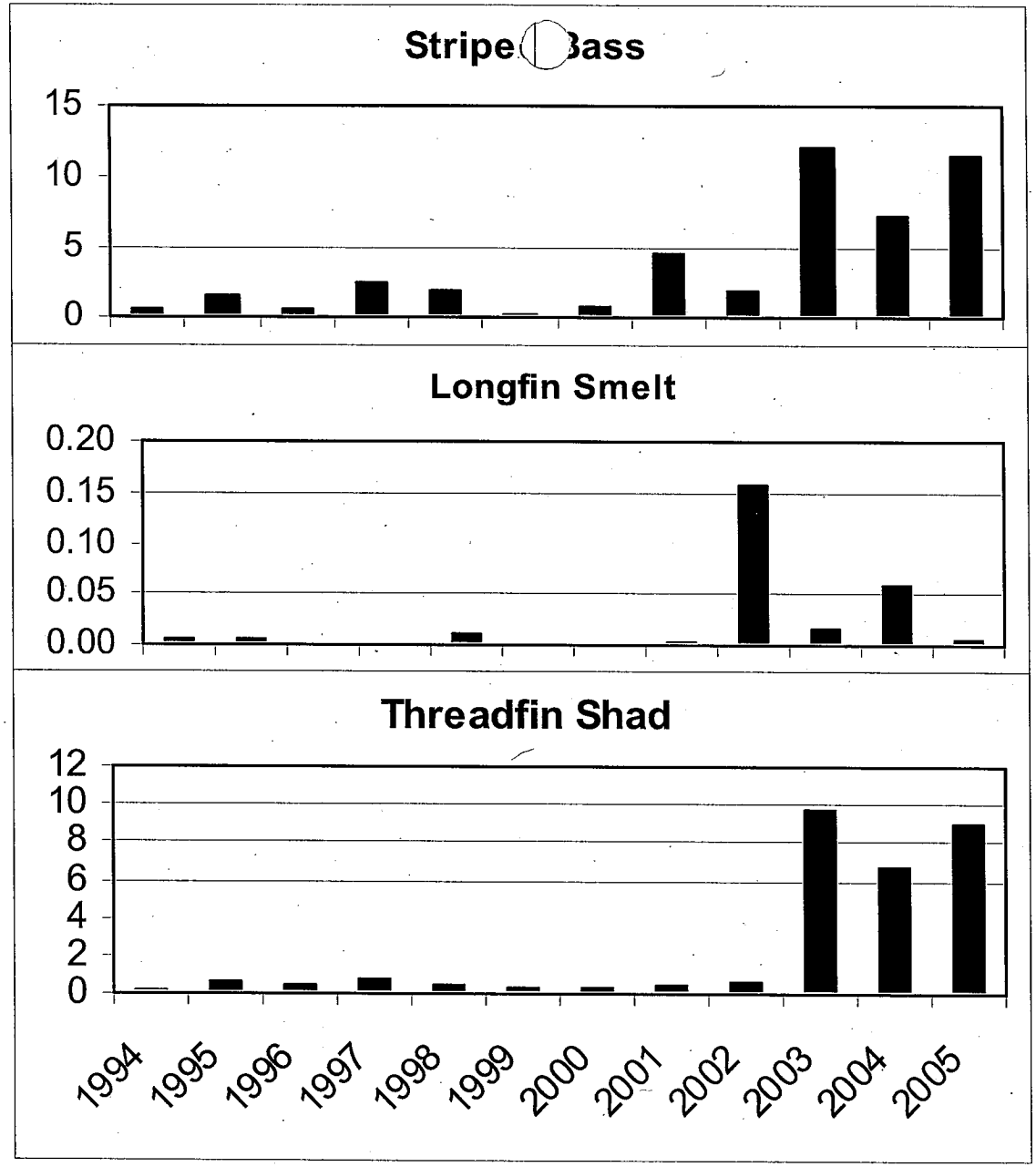



Figure 3. Winter salvage density (#/acre ft pumped) of three POD fishes scaled (divided) by the previous Fall Midwater Trawl abundance indices.

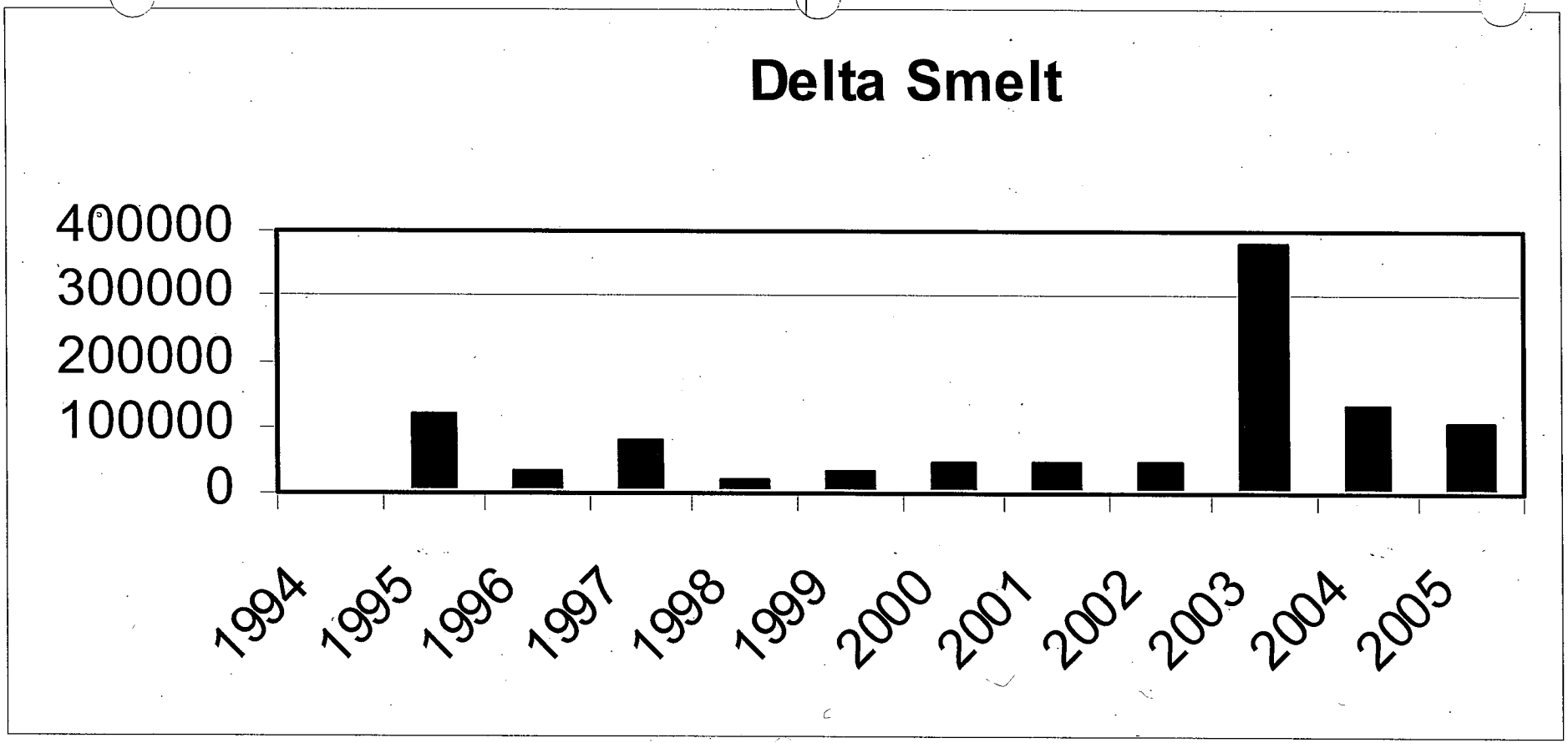



Figure 4. Winter salvage density (#/acre ft pumped) of delta smelt scaled (divided) by the previous Fall Midwater Trawl abundance indices.

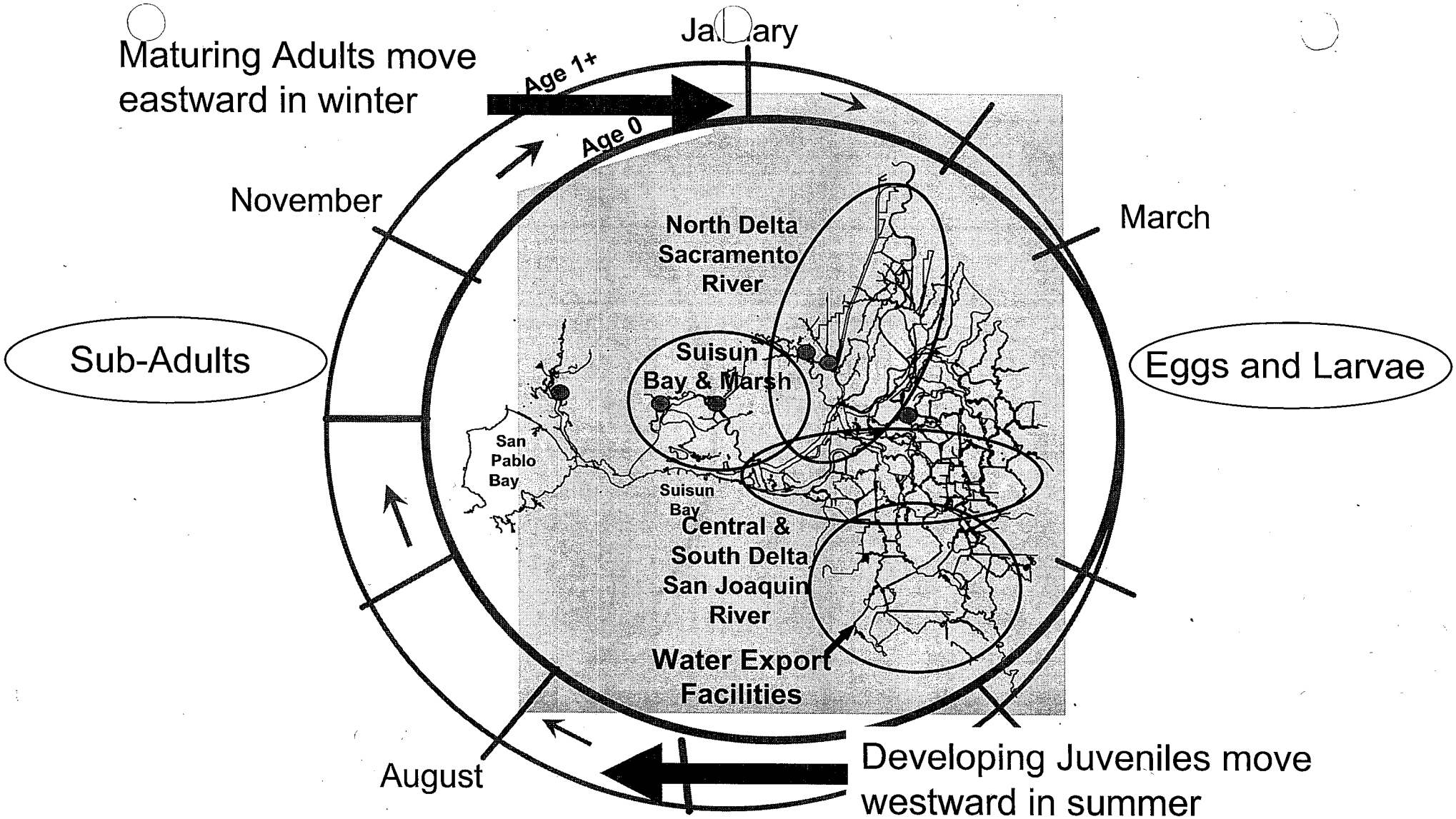
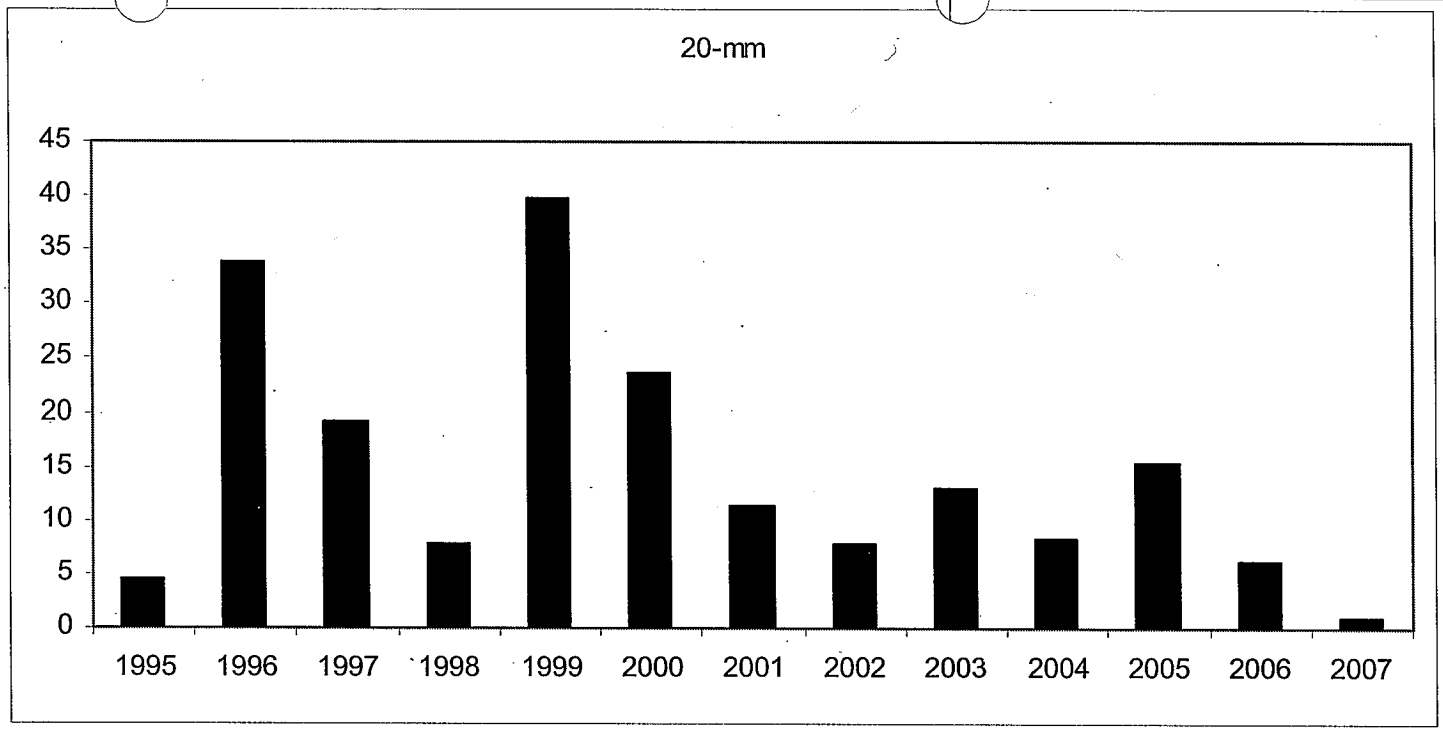



Figure 5. Delta smelt life history and general migration patterns: in winter and spring, maturing smelt move from the river confluence, Suisun Bay and Marsh eastward preparing to spawn, and become more vulnerable to entrainment by south delta export facilities. Subsequent progeny also remain vulnerable until they are able to swim and warm water temperatures drive them westward from the south delta.




| Year | Index |
|---|---|
| 1995 | 4.4 |
| 1996 | 33.9 |
| 1997 | 19.3 |
| 1998 | 7.7 |
| 1999 | 39.7 |
| 2000 | 23.8 |
| 2001 | 11.3 |
| 2002 | 7.7 |
| 2003 | 13.1 |
| 2004 | 8.2 |
| 2005 | 15.5 |
| 2006 | 6.2 |
| 2007 | 1.0 |

Figure 6. The 20mm survey delta smelt index by year, 1995-2007. Data processing for 2007 is not yet complete; data should be treated as preliminary and subject to revision.

# Attachment 14-D

# EXHIBIT 5

CENTRAL VALLEY OPERATIONS OFFICE

DELTA SMELT AND SPLITTAIL

May-07

Note: Bold numbers are not verified by DFG.

| DATE | [redacted] | | | | Splittail | | | | Pumping | | | | | | Delta Smelt Daily Density | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Daily Total | | Combined | | Daily Total | | Combined | | Daily Total In CFS | | | Daily Total In Acre Feet | | | | |
| | SWP | CVP | Daily Total | 14-Day Average | SWP | CVP | Daily Total | 14-Day Average | Banks | Tracy | Combined | Banks | Tracy | Combined | SWP | CVP |
| 1-May-07 | 0 | 12 | 12 | 2 | 4 | 0 | 4 | 2 | 531 | 849 | 1,380 | 1,054 | 1,684 | 2,738 | 0.0 | 7.1 |
| 2-May-07 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 872 | 560 | 1,432 | 1,730 | 1,110 | 2,840 | 0.0 | 0.0 |
| 3-May-07 | 0 | 0 | 0 | 1 | 4 | 0 | 4 | 1 | 677 | 848 | 1,525 | 1,342 | 1,682 | 3,024 | 0.0 | 0.0 |
| 4-May-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 676 | 846 | 1,522 | 1,340 | 1,679 | 3,019 | 0.0 | 0.0 |
| 5-May-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 675 | 844 | 1,519 | 1,339 | 1,674 | 3,013 | 0.0 | 0.0 |
| 6-May-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 673 | 855 | 1,528 | 1,335 | 1,695 | 3,030 | 0.0 | 0.0 |
| 7-May-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 679 | 693 | 1,372 | 1,347 | 1,375 | 2,722 | 0.0 | 0.0 |
| 8-May-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 578 | 852 | 1,429 | 1,146 | 1,689 | 2,835 | 0.0 | 0.0 |
| 9-May-07 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 652 | 853 | 1,504 | 1,293 | 1,691 | 2,984 | 0.0 | 0.0 |
| 10-May-07 | 0 | 12 | 12 | 2 | 0 | 0 | 0 | 1 | 532 | 853 | 1,385 | 1,056 | 1,691 | 2,747 | 0.0 | 7.1 |
| 11-May-07 | 0 | 48 | 48 | 5 | 0 | 0 | 0 | 1 | 538 | 849 | 1,387 | 1,067 | 1,684 | 2,751 | 0.0 | 28.5 |
| 12-May-07 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 530 | 849 | 1,379 | 1,052 | 1,683 | 2,735 | 0.0 | 0.0 |
| 13-May-07 | 0 | 12 | 12 | 6 | 0 | 0 | 0 | 1 | 786 | 850 | 1,637 | 1,560 | 1,686 | 3,246 | 0.0 | 7.1 |
| 14-May-07 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 1 | 661 | 844 | 1,505 | 1,312 | 1,674 | 2,986 | 0.0 | 0.0 |
| 15-May-07 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 521 | 853 | 1,374 | 1,034 | 1,692 | 2,726 | 0.0 | 0.0 |
| 16-May-07 | 0 | 0 | 0 | 5 | 0 | 12 | 12 | 1 | 302 | 852 | 1,154 | 600 | 1,689 | 2,289 | 0.0 | 0.0 |
| 17-May-07 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 275 | 855 | 1,130 | 545 | 1,696 | 2,241 | 0.0 | 0.0 |
| 18-May-07 | 0 | 0 | 0 | 5 | 4 | 0 | 4 | 1 | 317 | 852 | 1,169 | 629 | 1,689 | 2,318 | 0.0 | 0.0 |
| 19-May-07 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 273 | 855 | 1,127 | 541 | 1,695 | 2,236 | 0.0 | 0.0 |
| 20-May-07 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 272 | 850 | 1,122 | 540 | 1,686 | 2,226 | 0.0 | 0.0 |
| 21-May-07 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 1 | 271 | 856 | 1,127 | 538 | 1,698 | 2,236 | 0.0 | 0.0 |
| 22-May-07 | 0 | 0 | 0 | 5 | 4 | 0 | 4 | 1 | 273 | 852 | 1,125 | 541 | 1,690 | 2,231 | 0.0 | 0.0 |
| 23-May-07 | 0 | 24 | 24 | 7 | 2 | 24 | 26 | 3 | 798 | 848 | 1,646 | 1,583 | 1,682 | 3,265 | 0.0 | 14.3 |
| 24-May-07 | 0 | 24 | 24 | 8 | 0 | 0 | 0 | 3 | 359 | 849 | 1,208 | 713 | 1,683 | 2,396 | 0.0 | 14.3 |
| 25-May-07 | 2 | 0 | 2 | 4 | 0 | 0 | 0 | 3 | 358 | 851 | 1,209 | 710 | 1,688 | 2,398 | 2.8 | 0.0 |
| 26-May-07 | 22 | 24 | 46 | 8 | 0 | 12 | 12 | 4 | 358 | 845 | 1,203 | 711 | 1,676 | 2,387 | 30.9 | 14.3 |
| 27-May-07 | 24 | 24 | 48 | 10 | 0 | 48 | 48 | 8 | 260 | 854 | 1,114 | 516 | 1,693 | 2,209 | 46.5 | 14.2 |
| 28-May-07 | 20 | 0 | 20 | 12 | 0 | 24 | 24 | 9 | 321 | 853 | 1,173 | 636 | 1,691 | 2,327 | 31.4 | 0.0 |
| 29-May-07 | 58 | 12 | 70 | 17 | 0 | 0 | 0 | 9 | 315 | 853 | 1,167 | 624 | 1,691 | 2,315 | 92.9 | 7.1 |
| 30-May-07 | 46 | 24 | 70 | 22 | 0 | 12 | 12 | 9 | 315 | 854 | 1,169 | 624 | 1,694 | 2,318 | 73.7 | 14.2 |
| 31-May-07 | 40 | 0 | 40 | 25 | 0 | 0 | 0 | 9 | 261 | 856 | 1,116 | 517 | 1,697 | 2,214 | 77.4 | 0.0 |
| Total | 212 | 216 | 428 | XXXX | 18 | 132 | 150 | XXXX | 14,911 | 25,927 | 40,838 | 29,575 | 51,427 | 81,002 | XXXX | XXXX |

Delta Smelt Incidental Take Levels

Below Normal Water Year Type

Delta smelt risk assessment matrix (DSRM) Adult level of concern = 892

Re-consultation level for May = 30,500

CENTRAL VALLEY OPERATIONS OFFICE

DELTA SMELT AND SPLITTAIL

June-07

Note: Bold numbers are not verified by DFG.

| DATE | Daily Total SWP | Daily Total CVP | Combined Daily Total | Combined 14-Day Average | Splittail Daily Total SWP | Splittail Daily Total CVP | Splittail Combined Daily Total | Splittail Combined 14-Day Average | Pumping Daily Total In CFS Banks | Pumping Daily Total In CFS Tracy | Pumping Daily Total In CFS Combined | Pumping Daily Total In Acre Feet Banks | Pumping Daily Total In Acre Feet Tracy | Pumping Daily Total In Acre Feet Combined | Delta Smelt Daily Density SWP | Delta Smelt Daily Density CVP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-Jun-07 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 9 | 0 | 852 | 852 | 0 | 1,689 | 1,689 | #DIV/0! | 0.0 |
| 2-Jun-07 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 9 | 0 | 853 | 853 | 0 | 1,692 | 1,692 | #DIV/0! | 0.0 |
| 3-Jun-07 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 9 | 0 | 854 | 854 | 0 | 1,694 | 1,694 | #DIV/0! | 0.0 |
| 4-Jun-07 | 0 | 0 | 0 | 25 | 0 | 0 | 0 | 9 | 0 | 858 | 858 | 0 | 1,702 | 1,702 | #DIV/0! | 0.0 |
| 5-Jun-07 | 0 | 0 | 0 | 25 | 0 | 24 | 24 | 10 | 0 | 851 | 851 | 0 | 1,687 | 1,687 | #DIV/0! | 0.0 |
| 6-Jun-07 | 0 | 0 | 0 | 23 | 0 | 12 | 12 | 9 | 0 | 850 | 850 | 0 | 1,685 | 1,685 | #DIV/0! | 0.0 |
| 7-Jun-07 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 9 | 0 | 847 | 847 | 0 | 1,680 | 1,680 | #DIV/0! | 0.0 |
| 8-Jun-07 | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 9 | 0 | 845 | 845 | 0 | 1,677 | 1,677 | #DIV/0! | 0.0 |
| 9-Jun-07 | 0 | 0 | 0 | 18 | 0 | 0 | 0 | 9 | 0 | 849 | 849 | 0 | 1,683 | 1,683 | #DIV/0! | 0.0 |
| 10-Jun-07 | 27 | 0 | 27 | 16 | 0 | 0 | 0 | 5 | 90 | 845 | 935 | 178 | 1,677 | 1,855 | 151.7 | 0.0 |
| 11-Jun-07 | 9 | 0 | 9 | 15 | 0 | 0 | 0 | 3 | 90 | 846 | 937 | 179 | 1,679 | 1,858 | 50.3 | 0.0 |
| 12-Jun-07 | 30 | 0 | 30 | 13 | 0 | 0 | 0 | 3 | 89 | 853 | 941 | 176 | 1,691 | 1,867 | 170.5 | 0.0 |
| 13-Jun-07 | 9 | 48 | 57 | 12 | 0 | 0 | 0 | 3 | 89 | 2,009 | 2,098 | 177 | 3,984 | 4,161 | 50.8 | 12.0 |
| 14-Jun-07 | 9 | 0 | 9 | 9 | 0 | 12 | 12 | 3 | 90 | 2,526 | 2,616 | 178 | 5,010 | 5,188 | 50.6 | 0.0 |
| 15-Jun-07 | 18 | 0 | 18 | 11 | 0 | 0 | 0 | 3 | 96 | 2,575 | 2,671 | 191 | 5,107 | 5,298 | 94.2 | 0.0 |
| 16-Jun-07 | 9 | 0 | 9 | 11 | 0 | 24 | 24 | 5 | 97 | 2,575 | 2,672 | 192 | 5,108 | 5,300 | 46.9 | 0.0 |
| 17-Jun-07 | 168 | 12 | 180 | 24 | 0 | 60 | 60 | 9 | 495 | 2,697 | 3,191 | 981 | 5,349 | 6,330 | 171.3 | 2.2 |
| 18-Jun-07 | 90 | 0 | 90 | 31 | 0 | 0 | 0 | 9 | 400 | 2,689 | 3,088 | 793 | 5,333 | 6,126 | 113.5 | 0.0 |
| 19-Jun-07 | 90 | 0 | 90 | 37 | 2 | 0 | 2 | 8 | 840 | 3,363 | 4,203 | 1,666 | 6,671 | 8,337 | 54.0 | 0.0 |
| 20-Jun-07 | 9 | 0 | 9 | 38 | 0 | 24 | 24 | 9 | 717 | 3,754 | 4,471 | 1,422 | 7,447 | 8,869 | 6.3 | 0.0 |
| 21-Jun-07 | 30 | 0 | 30 | 40 | 0 | 12 | 12 | 10 | 932 | 3,525 | 4,456 | 1,848 | 6,991 | 8,839 | 16.2 | 0.0 |
| 22-Jun-07 | 57 | 0 | 57 | 44 | 0 | 0 | 0 | 10 | 934 | 4,017 | 4,950 | 1,852 | 7,967 | 9,819 | 0.0 | 0.0 |
| 23-Jun-07 | 15 | 0 | 15 | 45 | 0 | 0 | 0 | 10 | 945 | 4,278 | 5,223 | 1,874 | 8,486 | 10,360 | 8.0 | 0.0 |
| 24-Jun-07 | 24 | 0 | 24 | 45 | 0 | 0 | 0 | 10 | 587 | 4,211 | 4,798 | 1,164 | 8,352 | 9,516 | 20.6 | 0.0 |
| 25-Jun-07 | 0 | 0 | 0 | 44 | 0 | 12 | 12 | 10 | 192 | 4,279 | 4,471 | 381 | 8,488 | 8,869 | 0.0 | 0.0 |
| 26-Jun-07 | 30 | 0 | 30 | 44 | 0 | 12 | 12 | 11 | 324 | 4,268 | 4,592 | 642 | 8,466 | 9,108 | 46.7 | 0.0 |
| 27-Jun-07 | 327 | 0 | 327 | 63 | 0 | 0 | 0 | 11 | 847 | 4,254 | 5,101 | 1,681 | 8,437 | 10,118 | 194.5 | 0.0 |
| 28-Jun-07 | 30 | 0 | 30 | 65 | 0 | 0 | 0 | 10 | 856 | 4,270 | 5,125 | 1,697 | 8,469 | 10,166 | 17.7 | 0.0 |
| 29-Jun-07 | 78 | 0 | 78 | 69 | 0 | 0 | 0 | 10 | 878 | 4,277 | 5,156 | 1,742 | 8,484 | 10,226 | 44.8 | 0.0 |
| 30-Jun-07 | 390 | 0 | 390 | 96 | 0 | 0 | 0 | 9 | 1,360 | 4,431 | 5,791 | 2,698 | 8,789 | 11,487 | 144.6 | 0.0 |
| Total | 1,449 | 60 | 1,509 | XXXX | 2 | 192 | 194 | XXXX | 10,946 | 74,199 | 85,145 | 21,712 | 147,174 | 168,886 | XXXX | XXXX |

Delta Smelt Incidental Take Levels

Below Normal Water Year Type

Delta smelt risk assessment matrix (DSRM) Adult level of concern = 892

Re-consultation level for June = 33,200

CENTRAL VALLEY OPERATIONS OFFICE

DELTA SMELT AND SPLITTAIL

July-07

Note: Bold numbers are not verified by DFG.

| DATE | [redacted] | | | | Splittail | | | | Pumping | | | | | | Delta Smelt Daily Density | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Daily Total | | Combined | | Daily Total | | Combined | | Daily Total In CFS | | | Daily Total In Acre Feet | | | | |
| | SWP | CVP | Daily Total | 14-Day Average | SWP | CVP | Daily Total | 14-Day Average | Banks | Tracy | Combined | Banks | Tracy | Combined | SWP | CVP |
| 1-Jul-07 | 246 | 12 | 258 | 102 | 2 | 60 | 62 | 9 | 5,301 | 3,926 | 9,228 | 10,515 | 7,788 | 18,303 | 23.4 | 1.5 |
| 2-Jul-07 | 311 | 0 | 311 | 118 | 7 | 12 | 19 | 10 | 6,032 | 4,452 | 10,484 | 11,965 | 8,830 | 20,795 | 26.0 | 0.0 |
| 3-Jul-07 | 13 | 0 | 13 | 112 | 1 | 0 | 1 | 10 | 5,485 | 4,442 | 9,926 | 10,879 | 8,810 | 19,689 | 1.2 | 0.0 |
| 4-Jul-07 | 18 | 0 | 18 | 113 | 11 | 48 | 59 | 13 | 5,833 | 4,385 | 10,218 | 11,570 | 8,698 | 20,268 | 1.6 | 0.0 |
| 5-Jul-07 | 21 | 0 | 21 | 112 | 0 | 48 | 48 | 15 | 5,301 | 4,440 | 9,741 | 10,514 | 8,807 | 19,321 | 2.0 | 0.0 |
| 6-Jul-07 | 9 | 0 | 9 | 109 | 0 | 24 | 24 | 17 | 5,755 | 4,358 | 10,113 | 11,415 | 8,644 | 20,059 | 0.8 | 0.0 |
| 7-Jul-07 | 12 | 0 | 12 | 109 | 36 | 0 | 36 | 20 | 5,562 | 4,346 | 9,909 | 11,033 | 8,621 | 19,654 | 1.1 | 0.0 |
| 8-Jul-07 | 6 | 0 | 6 | 107 | 3 | 0 | 3 | 20 | 5,459 | 4,344 | 9,803 | 10,828 | 8,617 | 19,445 | 0.6 | 0.0 |
| 9-Jul-07 | 6 | 0 | 6 | 108 | 21 | 0 | 21 | 20 | 5,807 | 4,354 | 10,161 | 11,518 | 8,636 | 20,154 | 0.5 | 0.0 |
| 10-Jul-07 | 6 | 0 | 6 | 106 | 0 | 24 | 24 | 21 | 5,624 | 4,406 | 10,031 | 11,156 | 8,740 | 19,896 | 0.5 | 0.0 |
| 11-Jul-07 | 0 | 0 | 0 | 83 | 24 | 12 | 36 | 24 | 6,200 | 4,385 | 10,585 | 12,298 | 8,697 | 20,995 | 0.0 | 0.0 |
| 12-Jul-07 | 6 | 0 | 6 | 81 | 9 | 0 | 9 | 24 | 6,258 | 4,386 | 10,644 | 12,413 | 8,699 | 21,112 | 0.5 | 0.0 |
| 13-Jul-07 | 0 | 0 | 0 | 75 | 6 | 0 | 6 | 25 | 6,423 | 4,391 | 10,815 | 12,741 | 8,710 | 21,451 | 0.0 | 0.0 |
| 14-Jul-07 | 6 | 0 | 6 | 48 | 36 | 0 | 36 | 27 | 6,985 | 4,365 | 11,350 | 13,855 | 8,657 | 22,512 | 0.4 | 0.0 |
| 15-Jul-07 | 6 | 0 | 6 | 30 | 36 | 12 | 48 | 26 | 7,986 | 4,354 | 12,340 | 15,840 | 8,636 | 24,476 | 0.4 | 0.0 |
| 16-Jul-07 | 24 | 0 | 24 | 10 | 6 | 0 | 6 | 26 | 6,441 | 4,353 | 10,794 | 12,775 | 8,635 | 21,410 | 1.9 | 0.0 |
| 17-Jul-07 | 6 | 0 | 6 | 9 | 16 | 0 | 16 | 27 | 6,878 | 4,376 | 11,254 | 13,642 | 8,680 | 22,322 | 0.4 | 0.0 |
| 18-Jul-07 | 3 | 0 | 3 | 8 | 15 | 12 | 27 | 24 | 7,055 | 4,382 | 11,437 | 13,993 | 8,692 | 22,685 | 0.2 | 0.0 |
| 19-Jul-07 | 0 | 0 | 0 | 6 | 36 | 12 | 48 | 24 | 7,317 | 4,367 | 11,684 | 14,514 | 8,662 | 23,176 | 0.0 | 0.0 |
| 20-Jul-07 | 0 | 0 | 0 | 6 | 0 | 0 | 0 | 23 | 6,930 | 4,363 | 11,293 | 13,746 | 8,654 | 22,400 | 0.0 | 0.0 |
| 21-Jul-07 | 0 | 0 | 0 | 5 | 0 | 12 | 12 | 21 | 6,993 | 4,391 | 11,384 | 13,871 | 8,710 | 22,581 | 0.0 | 0.0 |
| 22-Jul-07 | **0** | **0** | 0 | 5 | **0** | **0** | 0 | 21 | 6,893 | 4,379 | 11,271 | 13,672 | 8,685 | 22,357 | 0.0 | 0.0 |
| 23-Jul-07 | **0** | **0** | 0 | 4 | **0** | **0** | 0 | 19 | 6,681 | 4,385 | 11,066 | 13,252 | 8,698 | 21,950 | 0.0 | 0.0 |
| 24-Jul-07 | **0** | **0** | 0 | 4 | **0** | **12** | 12 | 18 | 6,895 | 4,418 | 11,313 | 13,676 | 8,763 | 22,439 | 0.0 | 0.0 |
| 25-Jul-07 | **0** | **0** | 0 | 4 | **0** | **0** | 0 | 16 | 4,799 | 4,458 | 9,256 | 9,518 | 8,842 | 18,360 | 0.0 | 0.0 |
| 26-Jul-07 | **0** | **0** | 0 | 3 | **0** | **0** | 0 | 15 | 8,024 | 4,443 | 12,467 | 15,916 | 8,813 | 24,729 | 0.0 | 0.0 |
| 27-Jul-07 | **0** | **0** | 0 | 3 | **0** | **0** | 0 | 15 | 7,732 | 4,467 | 12,199 | 15,336 | 8,860 | 24,196 | 0.0 | 0.0 |
| 28-Jul-07 | **0** | **0** | 0 | 3 | **12** | **0** | 12 | 13 | 7,271 | 4,427 | 11,698 | 14,422 | 8,781 | 23,203 | 0.0 | 0.0 |
| 29-Jul-07 | **0** | **0** | 0 | 2 | **0** | **0** | 0 | 10 | 7,144 | 4,464 | 11,608 | 14,170 | 8,855 | 23,025 | 0.0 | 0.0 |
| 30-Jul-07 | **0** | **0** | 0 | 1 | **9** | **0** | 9 | 10 | 6,983 | 4,434 | 11,416 | 13,850 | 8,794 | 22,644 | 0.0 | 0.0 |
| 31-Jul-07 | **0** | **0** | 0 | 0 | **0** | **12** | 12 | 9 | 6,999 | 4,420 | 11,420 | 13,883 | 8,768 | 22,651 | 0.0 | 0.0 |
| Total | 699 | 12 | 711 | XXXX | 286 | 300 | 586 | XXXX | 201,047 | 135,862 | 336,908 | 398,776 | 269,482 | 668,258 | XXXX | XXXX |

Delta Smelt Incidental Take Levels

Below Normal Water Year Type

Delta smelt risk assessment matrix (DSRM) Adult level of concern = 892

Re-consultation level for July = 2,500

# Attachment 14-E

# EXHIBIT 6

**From:** Greene, Sheila [mailto:sgreene@water.ca.gov]
**Sent:** Monday, February 07, 2005 11:48 AM
**To:** calfedda@water.ca.gov
**Subject:** Summary of DAT Conference Call 2/1/2005
**Attachments:** COLFLOSS.xls; Fry_SmoltChinook2005.ppt; JuvenileChinook2005.ppt; WRLOSS05.ppt; WRSLV05.ppt; DAT20050201.wpd; DAT20050201.doc

Summary of DAT Conference Call 2/01/2005

Participants: SGreene, VPoage, PCadrett, JWhite, TBoardman, ROlah, BOppenheim, BKinnear, PCoulston, EChappell, CReiner, PManza, JSnow, TBui, DSchuster, BHerbold, MMosses, RSitts

Conclusions and Recommendations
Last Friday, 1/28/05, there was a WOMT conference call to discuss the Delta Smelt Workgroup recommendation to reduce exports to a combined 1,500 cfs for one week due to high delta smelt salvage, high delta smelt salvage compared to low fall midwater trawl delta smelt index, and the delta smelt distribution from the first few days of the kodiak trawl. The Delta Smelt Work group will evaluate delta smelt salvage, and if salvage density decreases significantly, they will recommend resuming normal export operations. WOMT agreed to the recommendation. Each project will export 700 cfs starting on 2/1/05 for one week, unless otherwise notified. The Delta Smelt Workgroup is scheduled to meet Thursday, 2/3 in the afternoon.

There was a pulse of juvenile Chinook catch in the tributaries and Sacramento River down as far as the north Delta, associated with the storm last week. But no significant catch of non-clipped Chinook in the Chipps Island trawl or at the Delta export facilities. There was a significant increase in the number of clipped juvenile Chinook at the export facilities, but the tags have not yet been read. Most are likely from the Coleman late fall production release, but with the number of outstanding tags, it is possible we could reach the first level of concern for the January yearling spring run surrogate release from Coleman hatchery.

The salvage of steelhead at the export facilities increased significantly last week.

Next DAT call Tuesday, 2/8/2005, at 9:00 am, at 916/657-4111.

Chinook Monitoring

Upper Sacramento River
Red Bluff Diversion - Flow peaked at 33,000 cfs on 1/27/05, but has decreased since. The traps were damaged, and not operating from 1/27 through 1/29. Starting 1/30, three of the four traps have been operating. Daily

fall length Chinook passage increased from 17,000 on 1/26 to 555,000 on 1/30. There were no older juvenile Chinook. There were 2 clipped Chinook and 7 clipped steelhead. Flows are decreasing and currently at ~7,500 cfs. FWS assumes the substantial numbers of fry Chinook passed RBDD when the traps were out.

FWS posts biweekly reports on the Bay-Delta and Tributaries Project website, at

http://baydelta.ca.gov/Php/Special_Reports/red_bluff.php4

Mill Creek - Flow increased from 200 cfs to a daily average of 625 cfs on 1/27, and then decreased to 336 cfs. Turbidity increased from 3 NTU to 21.6 NTU to 6.6 NTU. Spring run fry catch increased from less than 10/day to 268/day on 1/27, and is gradually decreasing. Yearling spring run catch went from 0 to 2 on 2/29, then decreased. There were 600 spring run fry and 3 yearlings last week. No steelhead.

Deer Creek - Flow increased from 220 cfs to 700 cfs on 1/28, then decreased. Turbidity increased from 2.2 NTU to 8.2 NTU, then decreased. Spring run fry catch increased from 0 to 240/day on 1/30. Yearling spring run increased from nearly 0 to 7/day on 1/30. There were 474 spring run fry, and 14 yearling spring run last week.

Butte Creek - Flow and spring run fry catch peaked on 1/27. Catch had been ranging from 2,600/day to 36,000/day, then peaked at 225,000/day on 1/27. DFG was operating the two rotary screws traps primarily for tagging. They tagged their 400,000 juveniles and removed the trap on 1/27. Last brood year, they had the second highest number of returning adults, 10,200, and very low pre-spawning mortality, 410. The high spring run fry emigration corresponds with the adult spawners.

GCID - Moderately low catch of mostly fry and smolts. 1 clipped Chinook on 1/25.

Knights Landing - Flow increased and peaked at 25,280 cfs on 1/29. Turbidity increased from 18 NTU to 300 NTU. Fry/smolt catch increased from 5/trap-day to 1,100/trap-day. Older juvenile catch increased from 0 to 6/trap-day. 19 clipped Chinook and 54 clipped steelhead last week.

Delta

Lower Sac River seine - 19 fry, 17 older juvenile, and 2 clipped Chinook in one day of sampling.
Sac Area seine - 439 fry/smolts, 2 older juvenile Chinook last week. About the same as last week.

Sac Trawl - only 2 fry/smolts. A significant decrease over last week. 5 clipped steelhead. No delta smelt.
North Delta seine - 224 fry/smolts. A significant increase.
Central Delta seine - Significant increase. 70 fry/smolts and 21 older juvenile.

South Delta, SJR and Bay seines - none
Mossdale trawl - None last week, but 22 fry/smolts on Monday, 1/31.
Chipps - Catch decreased. 1 older juvenile and 21 clipped Chinook 11 adult delta smelt.

Salvage Facilities
Chinook - SWP - No non-clipped Chinook salvage at the SWP. 62 clipped Chinook salvaged last week. They are all Coleman late fall origin. CVP - 24 non-clipped older juvenile, and 132 clipped Chinook salvaged last week.

The loss of clipped Chinook was high over the last week and a half. The tags have not been read, but the outstanding loss is about 2,472. We assume most are from the Coleman late fall production release, but It is possible that we could reach the first level of concern for the January yearling spring run surrogate release. We will distribute the tag reading results when we receive them.

Total winter run length non-clipped loss for the season is 250 at the SWP and 31 at the CVP, for a total of 281.

Steelhead - SWP - 15 non-clipped steelhead and 274 clipped steelhead salvaged last week. CVP - 24 non-clipped steelhead, and 48 clipped salvage last week. This is a significant increase for clipped steelhead salvage. There have been releases from Coleman, Feather, American and Mokelumne hatcheries recently.

Delta Smelt - SWP - Steadily salvaging delta smelt. 498 delta smelt salvaged last week. The January total is 1,107. CVP - 348 delta smelt savaged last week. The January total is 540. The combined total is 1,647. We got close to the consultation level for January of 1,900 . The consultation level for February is 1,700. There is no ripeness data taken at the salvage facilities. We did exceed the December through March adult cumulative salvage concern level of 892, with two months to go. Delta smelt salvage density increased for two weeks, but has been decreasing slowly in the last three days.

Splittail - Continuing to salvage splittail. SWP - 115 adult splittail salvaged last week. CVP - 128 adult splittail salvaged at the CVP last week.

Kodiak Trawl Delta Smelt
Survey number 1 is complete. There was a total of 220 adults. The sex ratio is 1:1. The size is normal with all stations

reported. The distribution is mostly in Montezuma slough and at the confluence of the Sacramento and San Joaquin rivers. There are not a lot of delta smelt in the south Delta, except at the export facilities. All stations were sampled last week and the next survey starts 2/7. The distribution and size is better than what was reported last Friday but the level of concern is still the same based on the high salvage and low fall midwater trawl index.

The delta smelt kodiak trawl distribution map is available on the website -

http://www.delta.dfg.ca.gov/data/skt//DisplayMaps.asp

Operations

SWP - 6,500 cfs today. DWR is scheduling 700 cfs for the delta smelt curtailment for the next 7 days. The estimated EWA cost is 80 taf. Prior to this export curtailment, DWR was expecting to fill San Luis next week, therefore the MAs expected the cost of this action to spill. But, with this export curtailment, the operators expect the debt will likely not spill. Article 21 was delivered last week due to a special condition which was O'Neill was full and the SWP was not able to send water to southern California due to their flooding problems. Article 21 may become available soon, but EWA wouldn't spill until there is water in excess of demands and Article 21.

In the absence of the delta smelt curtailment, SWP exports would have been about 6,000 cfs to comply with the 35% E/I ratio for February.

San Luis, - 1,013 taf. Full is 1,062 taf. Since they can't send water to southern California, they filled faster.
Oroville - 1,750 cfs.

CVP - 4,350 cfs today. The CVP operators are scheduling 750 cfs for the delta smelt curtailment for the next 7 days. The estimated b2 cost is 50 taf. They were projecting to spill in March before the export curtailment, but now they aren't sure they will fill.

San Luis - 797 taf. Full is 962 taf.
Trinity - 300 cfs.
Clear Creek - 200 cfs.
Keswick - 3,700 cfs and being supported by b2.
Nimbus - 2,500 cfs. In flood control.
Stan - 225 cfs.

Flows

Sacramento at Freeport ~ 31,236 cfs.
San Joaquin at Vernalis ~ 4,908 cfs.

Outflow ~ 27,900 cfs.
14-day E/I ratio - 38.7%.
X2 ~ The 14-day running average Port Chicago EC was 4.4 on 1/31. The daily EC was 1.6 microseimens/cm. According to the EWA biologists, they projects must meet Chipps Island the entire month of February.

Delta Water Quality
Water quality great.

*Sheila Greene*
Staff Environmental Scientist
CA Department of Water Resources
Division of Environmental Services
916/227-7538 voice
916/227-7554 fax

# Attachment 14-F

# EXHIBIT 7

CENTRAL VALLEY OPERATIONS OFFICE

DELTA SMELT AND SPLITTAIL

February-05

Note: Bold numbers are not verified by DFG.

| DATE | Delta Smelt | | | | Splittail | | | | Pumping | | | | | | Delta Smelt Daily Density | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Daily Total In CFS | | | Daily Total In Acre Feet | | | | |
| | Daily Total | | Combined | | Daily Total | | Combined | | | | | | | | | |
| | SWP | CVP | Daily Total | 14-Day Average | SWP | CVP | Daily Total | 14-Day Average | Banks | Tracy | Combined | Banks | Tracy | Combined | SWP | CVP |
| 1-Feb-05 | 27 | 0 | 27 | 81 | 12 | 0 | 12 | 47 | 6,426 | 4,369 | 10,794 | 12,745 | 8,665 | 21,410 | 2.1 | 0.0 |
| 2-Feb-05 | 9 | 12 | 21 | 79 | 0 | 12 | 12 | 44 | 2,153 | 1,829 | 3,982 | 4,271 | 3,627 | 7,898 | 2.1 | 3.3 |
| 3-Feb-05 | 6 | 12 | 18 | 77 | 0 | 0 | 0 | 40 | 1,008 | 1,670 | 2,678 | 1,999 | 3,312 | 5,311 | 3.0 | 3.6 |
| 4-Feb-05 | 12 | 0 | 12 | 72 | 0 | 0 | 0 | 34 | 1,016 | 2,011 | 3,027 | 2,015 | 3,989 | 6,004 | 6.0 | 0.0 |
| 5-Feb-05 | 42 | 0 | 42 | 71 | 0 | 0 | 0 | 24 | 3,014 | 2,007 | 5,021 | 5,979 | 3,981 | 9,960 | 7.0 | 0.0 |
| 6-Feb-05 | 27 | 12 | 39 | 71 | 0 | 0 | 0 | 20 | 4,972 | 2,002 | 6,974 | 9,862 | 3,971 | 13,833 | 2.7 | 3.0 |
| 7-Feb-05 | 39 | 24 | 63 | 69 | 12 | 0 | 12 | 20 | 6,261 | 3,753 | 10,014 | 12,418 | 7,444 | 19,862 | 3.1 | 3.2 |
| 8-Feb-05 | 23 | 0 | 23 | 64 | 6 | **12** | 18 | 18 | 6,332 | 4,373 | 10,705 | 12,560 | 8,673 | 21,233 | 1.8 | 0.0 |
| 9-Feb-05 | 3 | 0 | 3 | 57 | 0 | 0 | 0 | 16 | 6,277 | 4,374 | 10,650 | 12,450 | 8,675 | 21,125 | 0.2 | 0.0 |
| 10-Feb-05 | 33 | 0 | 33 | 49 | 3 | 0 | 3 | 15 | 6,128 | 4,371 | 10,499 | 12,154 | 8,670 | 20,824 | 2.7 | 0.0 |
| 11-Feb-05 | 9 | 0 | 9 | 40 | 6 | 0 | 6 | 13 | 6,336 | 4,399 | 10,735 | 12,567 | 8,726 | 21,293 | 0.7 | 0.0 |
| 12-Feb-05 | 12 | 0 | 12 | 34 | 9 | 0 | 9 | 11 | 6,336 | 4,393 | 10,729 | 12,567 | 8,713 | 21,280 | 1.0 | 0.0 |
| 1[illegible]05 | 3 | 0 | 3 | 26 | 12 | 0 | 12 | 9 | 5,975 | 4,374 | 10,348 | 11,851 | 8,675 | 20,526 | 0.3 | 0.0 |
| 14-[illegible]-05 | **12** | **0** | 12 | 23 | **0** | **0** | 0 | 6 | 5,249 | 4,250 | 9,498 | 10,411 | 8,429 | 18,840 | 1.2 | 0.0 |
| 15-Feb-05 | **6** | **12** | 18 | 22 | **0** | **0** | 0 | 5 | 5,381 | 4,340 | 9,722 | 10,674 | 8,609 | 19,283 | 0.6 | 1.4 |
| 16-Feb-05 | **0** | **36** | 36 | 23 | **0** | **12** | 12 | 5 | 4,803 | 4,332 | 9,135 | 9,527 | 8,592 | 18,119 | 0.0 | 4.2 |
| 17-Feb-05 | **0** | **0** | 0 | 22 | **6** | **0** | 6 | 6 | 4,797 | 4,380 | 9,177 | 9,514 | 8,688 | 18,202 | 0.0 | 0.0 |
| 18-Feb-05 | **0** | **0** | 0 | 21 | **0** | **0** | 0 | 6 | 4,524 | 4,387 | 8,911 | 8,973 | 8,702 | 17,675 | 0.0 | 0.0 |
| 19-Feb-05 | **0** | **0** | 0 | 18 | **0** | **0** | 0 | 6 | 4,517 | 4,403 | 8,920 | 8,959 | 8,734 | 17,693 | 0.0 | 0.0 |
| 20-Feb-05 | **0** | **0** | 0 | 15 | **0** | **0** | 0 | 6 | 5,106 | 4,383 | 9,489 | 10,128 | 8,693 | 18,821 | 0.0 | 0.0 |
| 21-Feb-05 | **0** | **0** | 0 | 11 | **0** | **0** | 0 | 5 | 4,585 | 4,419 | 9,005 | 9,095 | 8,766 | 17,861 | 0.0 | 0.0 |
| 22-Feb-05 | **0** | **0** | 0 | 9 | **13** | **0** | 13 | 4 | 5,416 | 4,129 | 9,545 | 10,743 | 8,189 | 18,932 | 0.0 | 0.0 |
| 23-Feb-05 | **0** | **0** | 0 | 9 | **0** | **0** | 0 | 4 | 5,373 | 3,867 | 9,240 | 10,658 | 7,670 | 18,328 | 0.0 | 0.0 |
| 24-Feb-05 | **0** | **0** | 0 | 6 | **6** | **0** | 6 | 5 | 5,941 | 4,511 | 10,452 | 11,784 | 8,948 | 20,732 | 0.0 | 0.0 |
| 25-Feb-05 | **0** | **0** | 0 | 6 | **6** | **36** | 42 | 7 | 5,936 | 4,386 | 10,323 | 11,775 | 8,700 | 20,475 | 0.0 | 0.0 |
| 26-Feb-05 | **0** | **0** | 0 | 5 | **6** | **36** | 42 | 10 | 5,936 | 4,373 | 10,309 | 11,775 | 8,673 | 20,448 | 0.0 | 0.0 |
| 27-Feb-05 | **0** | **0** | 0 | 5 | **15** | **24** | 39 | 11 | 5,908 | 4,427 | 10,335 | 11,718 | 8,781 | 20,499 | 0.0 | 0.0 |
| 28-Feb-05 | **0** | **0** | 0 | 4 | **6** | **12** | 18 | 13 | 3,930 | 4,373 | 8,303 | 7,796 | 8,673 | 16,469 | 0.0 | 0.0 |
| Total | 263 | 108 | 371 | XXXX | 118 | 144 | 262 | XXXX | 139,636 | 108,882 | 248,518 | 276,968 | 215,968 | 492,936 | XXXX | XXXX |

Delta Smelt Incidental Take Levels

Below Normal Water Year Type

Delta smelt risk assessment matrix (DSRM) Adult level of concern = 892

Re-consultation level for February = 1,700

# Attachment 14-G

# EXHIBIT 8

Delta Smelt Working Group Meeting Minutes

July 10, 2006

Participating: Gonzalo Castillo (USFWS), Kevin Fleming (DFG), Bruce Herbold (USEPA), Ted Sommer (DWR), Matt Nobriga (DWR), Ann Lubas-Williams (USBR), Tracy Pettit (DWR), Tracy Hinojosa (DWR), Ryan Olah (USFWS), convener and scribe, Jim White (DFG), and Lenny Grimaldo (DWR).

For Discussion:
Continue discussions on possible fish actions for upcoming season

Recommendation for WOMT: The Working Group formally requests that DWR provide initial estimates of the cost in terms of water volumes to first achieve and then maintain a net outflow of 11,400 cfs at Chipps Island from September through November.

Minutes:

Ted Sommer presented an outline of potential actions (see attachment 1) that the Working Group used to rank potential actions to protect delta smelt. The Working Group developed a ranking system for each of the potential actions to clarify the action's biological basis and its likelihood of successful implementation in the next 12 months:

| Biological Basis the next 12 months | | Likelihood of successful implementation in | |
|---|---|---|---|
| 0. | None (for the specific season) | | |
| 1. | Reasonable biology | A. | Not worth Doing |
| 2. | Supporting pattern in data | B. | Maybe |
| 3. | Correlation Present | C. | Very Likely |
| 4. | Some causation known | | |
| 5. | Strongly supported by evidence | | |

Based on these criteria, the Working Group then assigned a ranking to each hypothesis under each season. These rankings were intended to apply only to water year 2007, and could change based on hydrology, new data, or species status.

Based on this exercise, the Working Group identified the need for a description of likely conditions this fall based on hydrologic forecast modeling. Since outflows may potentially be as low as 7,000 cfs net outflow, the Working Group requested that the following initial modeling take place:

- Based on the latest hydrologic forecasts, what would be the cost in terms of water volumes to first achieve and then maintain a net outflow of 11,400 cfs at Chipps Island from September through November? [Note that between the time that the meeting occurred and the notes were produced, DWR estimated that maintaining 11,400 cfs at Chipps Island would require

approximately 600 TAF of water in the median hydrology, and approximately twice as much in the dry hydrology.]

Additional modeling:

- Assuming that the 11,400 cfs net outflow was implemented, what would be the flows in Old and Middle River, given a variety of combined inflows and export rates? The best approach to this may be to vary San Joaquin River flow, export flow and Old/Middle River flow in a single nomograph at some specific Sacramento River flow. Several nomographs could be produced for various increments of Sacramento River flow; this concept needs to be refined and, perhaps, simplified before a formal request is made of DWR.

Action Items:

1. DWR will perform the initially-requested modeling and the group will then convene to discuss the results.
2. The Working Group will refine their request for additional modeling to examine flows at Old and Middle Rivers.

Next Scheduled Meeting: TBA, based on modeling results.

Submitted,

RO/vp

## Attachment 1

# ALTERNATIVES TO IMPROVE DELTA SMELT ABUNDANCE DURING THE NEXT YEAR

**Draft Revised July 17, 2006**

### Assumptions

- This review focuses on actions that could be realistically conducted during the next year.
- The list is intended as talking points to evaluate the potential efficacy and feasibility of alternatives. It is not a set of recommendations.
- There are likely other actions—this is a starting point!
- Each action includes a partial list of useful metrics of the success of that alternative.
- Additional information is needed to document the supporting evidence for each alternative.

### Fall Actions (September-November)

1. Habitat Improvements

Hypothesis: Higher fall flows (total delta outflow) will increase the amount of habitat for delta smelt.

Measures:
Fish: FMWT distribution, following year's TNS abundance, condition, size, energy density,growth.
Clams: Biomass, distribution, grazing rate(may be affecting habitat quality).
Food supply: Zooplankton density, Chlorophyll a, smelt diets.
Habitat: EQ index (turbidity, ec), X2
**Ranking: 3/4 C-We have a relationship between habitat and summer production and fall flows are forecasted to be low (maybe around 7,000 cfs ouflow)**

2. Reduce Entrainment Losses (Mortality)

Hypothesis: Increased (more positive) Old and Middle River flows will reduce losses of adults.

Measures:
Fish: FMWT distribution, TNS abundance, salvage,
Hydrology: Exports, OR & MR flows.
Modeling: ptm experiments
**Ranking: 3C-based on Pete Smith of USGS's relationship**

Hypothesis: Reducing Delta Cross Channel closures will reduce losses of adults.

Measures:
Fish: FMWT distribution, TNS abundance, salvage,
Hydrology: Exports, OR & MR flows.

Modeling: ptm experiments

**Ranking: 2C-based on conceptual understanding of Delta hydrodynamics and recent ptm work.**

3. Food Supply

Hypothesis: Increased San Joaquin River flow to Suisun Bay will deliver more phytoplankton and zooplankton to support adults and egg production.

Measures:

Fish: TNS & FMWT abundance, condition, size, energy density.
Clams: Biomass, distribution, grazing rate.
Food supply: Zooplankton density, chlorophyll a, smelt diets.
Hydrology: SJR flow, exports, OR & MR flows, particle tracking.

**Ranking: 1B**

Hypothesis: Increased flow from Yolo Bypass (e.g. managed wetlands) will deliver more phytoplankton and zooplankton to support adults and egg production.

Measures:

Fish: 20 mm abundance and distribution, TNS & FMWT abundance, condition, size, energy density, salvage.
Clams: Biomass, distribution, grazing rate.
Food supply: Zooplankton density, chlorophyll a, smelt diets.
Hydrology: Sac flow, Cache Slough flow, particle tracking, hydrodynamics?

**Ranking: 1B**

**Overbite Clam Hypothesis: Additional outflow will restrict Asian clam abundance**
**Ranking: 2B**

**Winter Actions (December-February)**

1. Habitat Improvements

Hypothesis: Higher flows during late winter will increase the amount of habitat (e.g. X2) for delta smelt.

Measures:

Fish: FMWT & Kodiak trawl distribution, subsequent TNS abundance, condition, energy density, growth.
Habitat: X2

**Ranking: 0**

2. Reduce Losses (Mortality)

Hypothesis: Export reduction during "first flush" of delta tributaries will reduce losses of adults.

Measures:

Fish: FMWT distribution, TNS abundance, salvage,
Hydrology: Exports, inflow, outflow.
Modeling: ptm experiments

**Ranking: 4C-fish are entrained during these times, based on historical salvage and Pete Smith's USGS work**

Hypothesis: Increased (more positive) Old and Middle River flows will reduce losses of adults and result in a better spawning distribution.

Measures:

Fish: FMWT distribution, TNS abundance, salvage.
Hydrology: Exports, OR & MR flows.
Modeling: ptm experiments

**Ranking: 4C-fish are entrained during these times, based on historical salvage and Pete Smith's USGS work**

Hypothesis: Reducing Delta Cross Channel closures will reduce losses of adults and result in a better spawning distribution..

Measures:

Fish: FMWT distribution, TNS abundance, salvage,
Hydrology: Exports, OR & MR flows.
Modeling: ptm experiments

**Ranking: 2C-based on conceptual understanding of Delta hydrodynamics and recent ptm work.**

3. Food Supply

Hypothesis: Increased San Joaquin River flow to Suisun Bay will deliver more phytoplankton and zooplankton to support adult spawners. This action may also help to lower entrainment of fish.

Measures:

Fish: FMWT distribution, subsequent TNS abundance, condition, size, energy density, salvage.
Clams: Biomass, distribution, grazing rate.
Food supply: Zooplankton density, chlorophyll a, smelt diets.
Hydrology: SJR flow, exports, OR & MR flows.

**Ranking: 0-there is evidence that material if provided, but it is too late for spawning adults**

Hypothesis: Increased flow from Yolo Bypass will deliver more phytoplankton and zooplankton to promote egg production.

Measures:

Fish: subsequent 20 mm abundance and distribution, TNS & FMWT abundance, condition, size, energy density, salvage.
Clams: Biomass, distribution, grazing rate.
Food supply: Zooplankton density, chlorophyll a, smelt diets.
Hydrology: Sac flow, Cache Slough flow, particle tracking, hydrodynamics?

**Ranking: 0**

**Spring Actions (March-May)**

1. Habitat Improvements

Hypothesis: Higher flows during spring will increase the amount of habitat (e.g. X2) for delta smelt.

Measures:

Fish: 20 mm abundance, TNS abundance, condition, energy density, growth.
Habitat: X2
Food: Zooplankton, chlorophyll a, diets.

**Ranking: 2B-Supportive pattern-efforts have shown that more flow will increase habitat**

2. Reduce Losses (Mortality)

Hypothesis: Increased (more positive) Old and Middle River flows will reduce losses of larval and juvenile smelt.

Measures:

Fish: 20 mm abundance and distribution, TNS abundance & distribution, salvage, larval losses (e.g. Kimmerer method).
Hydrology: Exports, OR & MR flows.

**Ranking: 4C-based on USGS work**

3. Food Supply

Hypothesis: Increased San Joaquin River flow to Suisun Bay will deliver more phytoplankton and zooplankton to support young smelt. This action may also help to lower entrainment of fish.

Measures:

Fish: 20 mm abundance and distribution, TNS abundance and distribution, condition, size, energy density.
Clams: Biomass, distribution, grazing rate.
Food supply: Zooplankton density, chlorophyll a, smelt diets.
Hydrology: SJR flow, exports, OR & MR flows.

**Ranking: 2B-critical period, first feeding, these sources do provide food**

Hypothesis: Increased flow from Yolo Bypass (inflow or managed wetlands) will deliver more phytoplankton and zooplankton to support young smelt.

Measures:

Fish: 20 mm abundance and distribution, TNS abundance and distribution, condition, size, energy density.
Clams: Biomass, distribution, grazing rate.
Food supply: Zooplankton density, chlorophyll a, smelt diets.
Hydrology: Sac flow, Cache Slough flow, particle tracking, hydrodynamics?

**Ranking: 2B-critical period, first feeding, these sources do provide food**

**Summer Actions (June-August)**

1 Habitat Improvements

Hypothesis: Higher flows during summer will increase the amount of habitat (lower salinity, somewhat higher turbidity) for delta smelt.

Measures:

Fish: 20 mm abundance and water quality data, TNS & MWT abundance and water quality data, condition, energy density, growth.
Habitat: X2
Food: Zooplankton, chlorophyll a, diets.

**Ranking: 3B-Matt Nobriga's analysis does show a relationship**

Hypothesis: Increased turbidity via macrophyte removal will increase the amount of habitat for delta smelt.

Measures:

Fish: TNS & MWT abundance, condition, energy density, growth.
Habitat: EQ (ec & turbidity)
Food: Zooplankton, chlorophyll a, diets.

**Ranking: 2A-turbidity is higher in summer and smelt distribution is related to turbidity**

2 Food Supply

Hypothesis: Increased San Joaquin River flow to Suisun Bay will deliver more phytoplankton and zooplankton to support juvenile smelt. .

Measures:

Fish: TNS & FMWT abundance, condition, size, energy density.
Clams: Biomass, distribution, grazing rate.
Food supply: Zooplankton density, chlorophyll a, smelt diets.
Hydrology: SJR flow, exports, OR & MR flows, particle tracking.

**Ranking: 4B-good evidence here-these sources both provide food**

Hypothesis: Increased flow from Yolo Bypass (inflow or managed wetlands) will deliver more phytoplankton and zooplankton to support young smelt.

Measures:

Fish: 20 mm abundance and distribution, TNS & FMWT abundance, condition, size, energy density.
Clams: Biomass, distribution, grazing rate.
Food supply: Zooplankton density, chlorophyll a, smelt diets.
Hydrology: Sac flow, Cache Slough flow, particle tracking, hydrodynamics?

**Ranking: 4B-good evidence here-these sources both provide food**

Delta Smelt Working Group Meeting/Conference Call Minutes

August 21, 2006

Participating: Gonzalo Castillo (USFWS), Mike Chotkowski (USBR), Kevin Fleming (CDFG), Lenny Grimaldo (CDWR), Tracy Hinojosa (CDWR), Ann Lubas-Williams (USBR), Matt Nobriga (CDWR), Ryan Olah (USFWS), Tracy Pettit (USFWS), Jim White (CDFG) and Victoria Poage (USFWS, convener and scribe)

For Discussion:
1. Potential fall actions
2. Other actions
3. Fish Food Farm proposal

Recommendation for WOMT:
The Working Group agreed that the most defensible, critical period for using environmental water to protect delta smelt is the spring, when there is a clear link between flow, population distribution and entrainment risk. No data presently exists to demonstrate that the use of environmental water can influence the distribution of spawning adults, and the amounts of water needed to demonstrably improve fall habitat quantity/quality are unavailable. At times other than spring, it is likely that food limitation is a more critical problem than entrainment. The available data for striped bass and longfin smelt suggest that food limitation cannot be managed through the application of environmental water (attachment, Figure 1). Thus, it is very unlikely that small flow additions during fall could be reasonably expected to improve food availability for delta smelt. The Working Group therefore provisionally decided to recommend forestalling the use of EWA and other environmental water assets until the March-through-June period, when such use would have the greatest likelihood of a positive effect. The Working Group will, however, monitor Delta conditions and incidental take of adults, as per the 2005 OCAP B.O. and the Delta Smelt Risk Assessment Matrix. The DSWG may still recommend winter actions if adult delta smelt entrainment rises above the established threshold. The Working Group does not endorse the proposed fish food farm at Sherman Island.

Minutes:
*Entrainment.* At last Tuesday's WOMT meeting, Wim Kimmerer presented the results of an analysis of delta smelt entrainment that is part of an evaluation of the EWA that he is working on with co-authors. He estimates that at times, entrainment of delta smelt larvae may be as high as 30%, making it an important source of mortality. Larval losses due to entrainment may be over-ridden by food limitation during summer, but the Working Group is confident that it can minimize entrainment losses whereas mitigating for food limitation is more problematic and will require longer-term experiments and/or restoration programs.

*Fall Flows.* The Working Group discussed a proposal to maintain Delta outflow at a minimum of 7,000 cfs during September-December. Due to the wet spring, this action may be possible with little or no water cost. The Working Group is not opposed to this action, but did not recommend it because 7,000 cfs is not enough flow to detectably change physical habitat quantity/quality for delta smelt and will not likely change overbite clam distribution or abundance (attachment, Figure 2). Note that the quality of delta smelt fall habitat has recently been correlated with improved Summer Tow-Net Survey indices the following year (see notes from July 10, 2006). DWR generated new estimates on the water costs associated with proposed fall actions, based upon the most recent available forecast, as indicated below:

| Net Outflow | October – December | | | |
|---|---|---|---|---|
| 7,000 cfs | 50% Hydrology | 170 TAF | 90% Hydrology | 443 TAF |
| Net Outflow | September - December | | | |
| 11,400 cfs | 50% Hydrology | 911 TAF | 90% Hydrology | 1,460 TAF |

A net outflow of 11,400 cfs will maintain X2 at about Chipps Island if it is already at, or seaward of Chipps Island. Currently, X2 is near Collinsville about 10 km landward of Chipps Island. Fall physical habitat parameters do not respond linearly to changes in X2 position. Over the range of fall X2 positions observed since 1970, delta smelt habitat quality does not increase detectably until X2 passes seaward of Broad Slough (Figure 2 and Figure 3). The amount of environmental water required to move X2 seaward of Broad Slough to Chipps Island and keep it there throughout the fall is 3-4 times the annual EWA budget. Absent a formal and well-thought out experiment to develop an understanding of mechanisms underlying the fall habitat-summer abundance correlation, the DSWG cannot justify the water cost to maintain X2 at Chipps Island throughout the fall.

The Working Group believes that any fall flow control action should be set up as a full-fledged experiment to test competing hypotheses (i.e., reduction in clam distribution or abundance or reduction in entrainment susceptibility of adult delta smelt during winter or reduction in larval susceptibility to entrainment the following spring, etc.).

*Old River/Middle River Flows.* The Working Group recognized that Old River and Middle River flow targets could be achieved either by increasing San Joaquin River flow or by reducing exports, or more likely, through some combination of those actions. The Working Group believes that OR/MR flows that are neutral or positive through the spawning period of dry years are needed to minimize entrainment of larval delta smelt. These conditions are usually achieved for part of the spawning period through implementing the VAMP. However, the Working Group thinks that the VAMP starts too late in many years to be maximally protective. The target flows would depend to some extent on hydrology; if conditions in the spring are relatively wet, less flow could be needed, but in a 90% hydrology, OR/MR flows should be neutral or positive during a variable spring period based on water temperatures suitable for delta smelt spawning. In any hydrology, the Working Group would need to track fish distribution from survey data and determine the most appropriate flow targets as conditions develop. This year, San

Luis Reservoir may fill as early as December or January, which would potentially allow the Projects greater operational flexibility during spring 2007.

*First Flush.* Last winter, the Working Group looked at Delta conditions that could potentially influence the timing of adult delta smelt movement into areas wherein they would be subject to entrainment, and noted that in plots of the hydrograph against incidental take, it appeared that take increased in the days following the first major storms, as Sacramento River inflows increased. Definition of a "first flush" event may be based on precipitation or inflow; the Working Group will need to return to this concept in the next meeting.

*Fish Food Farm.* At last Tuesday's WOMT meeting, Wim Kimmerer presented evidence that for several species the most important source of mortality in the Delta is food limitation. The Working Group was asked to review DWR's proposal for an experimental food production facility on Sherman Island. The Working Group does not believe that the proposal should be implemented for several reasons. First, the proposed project is too small to make a detectable difference in estuarine food availability. Second, the project proposes to create a very shallow farm "habitat" for lower trophic level production during summer. This is likely to generate anoxic water similar to what often happens during fall in Suisun Marsh duck clubs. This poor-quality water would be discharged into a core delta smelt habitat area. Lastly, the project proposes to divert water onto Sherman Island from the surrounding waterways. Although the diverted water would be screened to exclude fish, larval fish may not be screened effectively. Furthermore, it cannot be screened to prevent nuisance organisms like Microcystis and overbite clam larvae that might have undesirable influences on what grows on the 'farm.'

Action Items:
None

Next Scheduled Meeting: Conference call, Wednesday, August 30, 2006, 3:00 pm

Submitted,
VLP

Attachment 1.

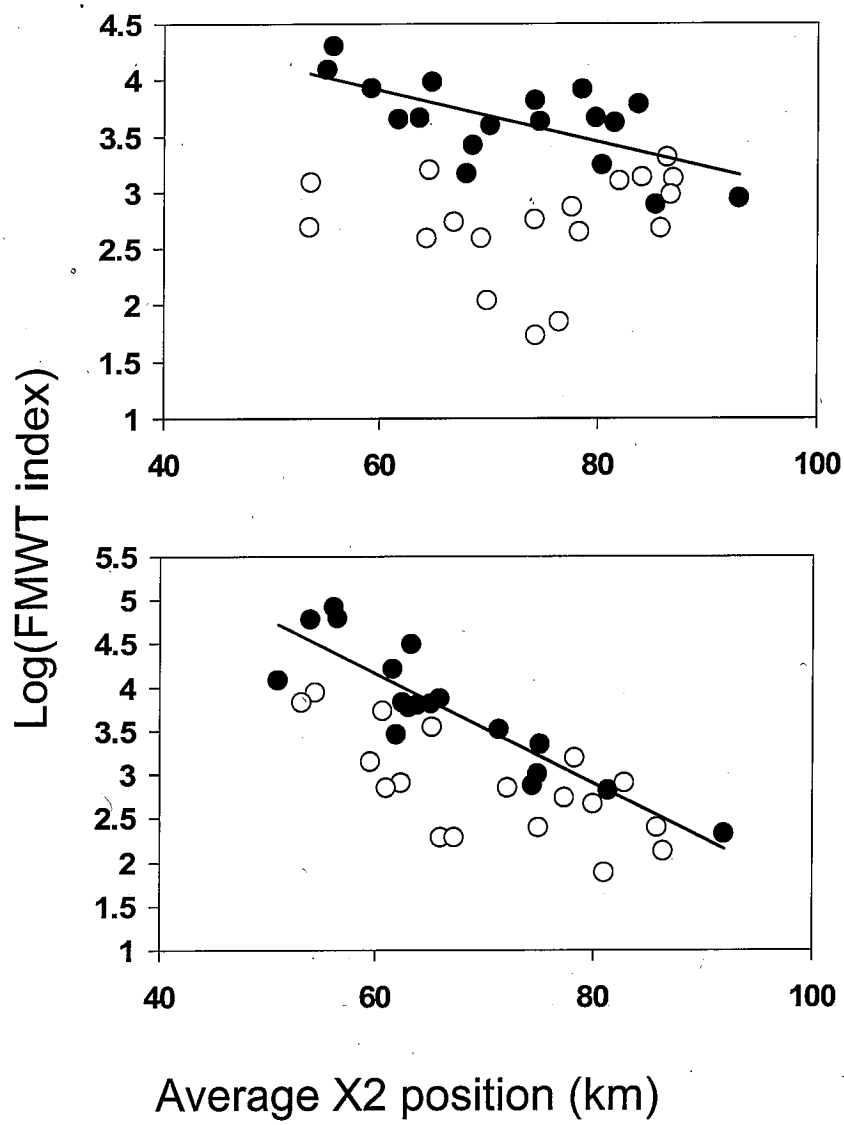



Figure 1. The 1967-2004 X2 relationships for striped bass (top panel) and longfin smelt (bottom panel) for before (solid symbols) and after (open symbols) the invasion of overbite clam, *Corbula amurensis*.

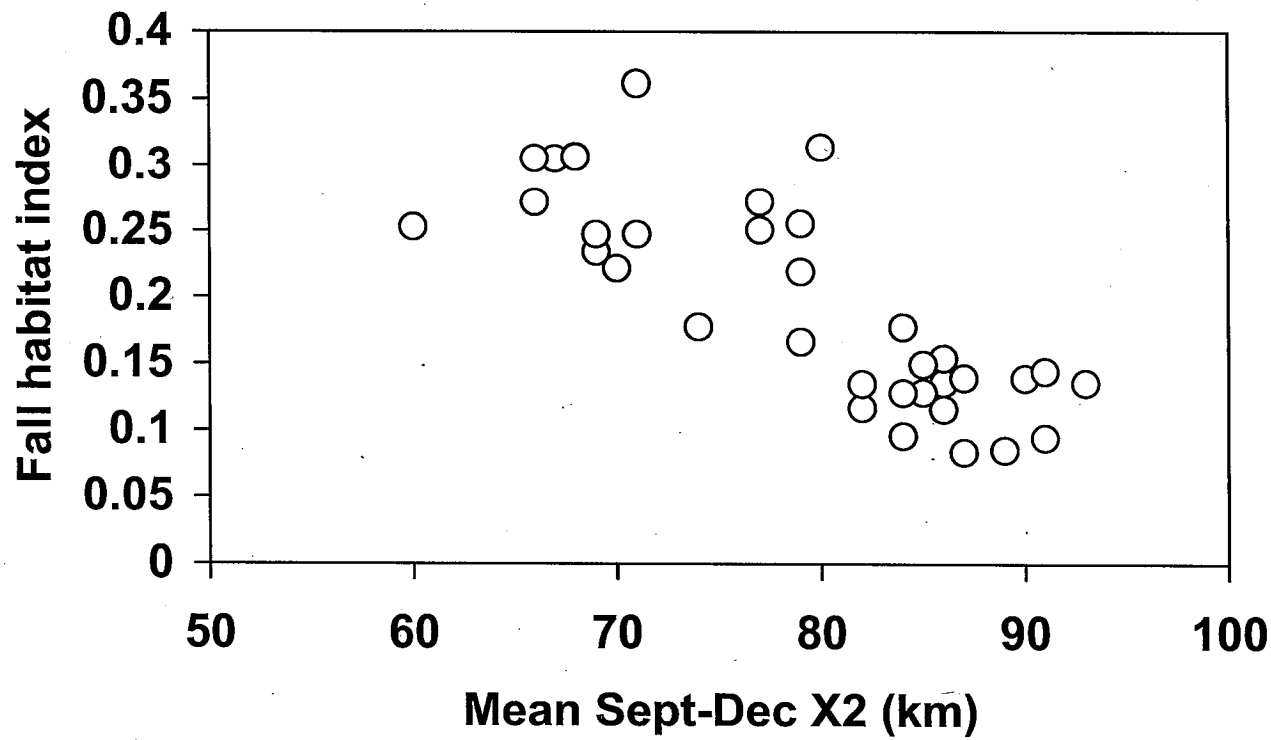



Figure 2. Relationship between fall X2 position and a delta smelt habitat index based on specific conductance, water clarity, and water temperature. Note that Chipps Island is approximately at X2 = 75 km and requires 11,400 cfs of Delta outflow to maintain its position there and higher flows to move it there from landward locations. Note that X2 was at approximately 85 km at the time of this meeting (August 2006).

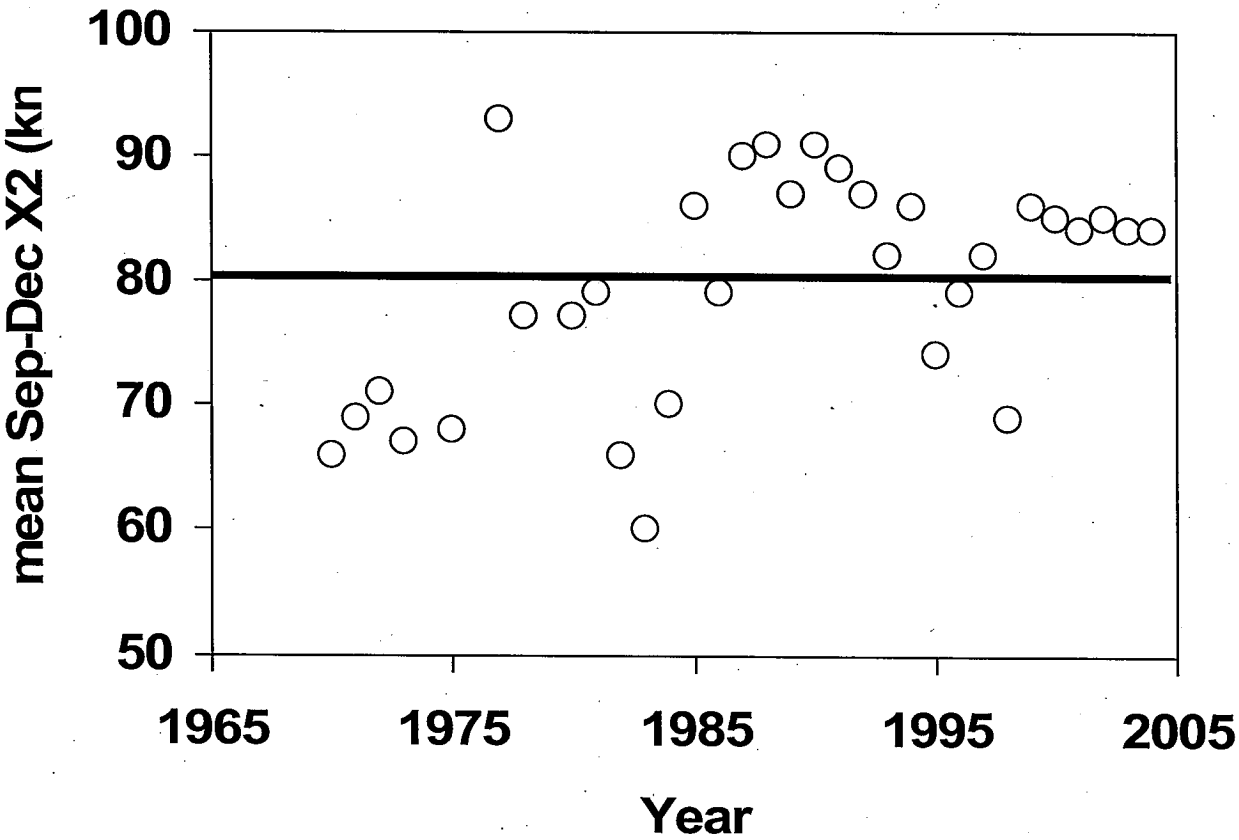



Figure 3. Time series of fall X2 positions for 1970-2004. The thick horizontal line denotes an X2 position near Broad Slough.

Delta Smelt Working Group Meeting Minutes

September 26, 2006

Participating: Gonzalo Castillo (USFWS), Mike Chotkowski (USBR), Kevin Fleming (CDFG), Bruce Herbold (USEPA), Tracy Hinojosa (CDWR), Peter Johnsen (USFWS), Ann Lubas-Williams (USBR), Matt Nobriga (CDWR), Kevin Sun (CDWR), Jim White (CDFG) and Victoria Poage (USFWS, convener and scribe)

For Discussion:
Action item from August 30:
1. Analyses of data pertinent to winter salvage events

Recommendation for WOMT:
The Working Group did not have a recommendation for WOMT.

The Working Group continued its August 30 discussion of the environmental factors that correspond to the onset or increases of salvage of pre-spawning adult delta smelt. The underlying hypothesis is that delta smelt cue on certain environmental factors when moving up the estuary to spawn, which may influence their vulnerability to entrainment at the export facilities. If environmental factors could be found that are sufficiently predictive of salvage, then modifications of Project operations could be designed to proactively avoid or minimize the entrainment of adult delta smelt. A small sub-group met previously to share data and prepare analyses for discussion by the entire Working Group. Analyses were intended to evaluate several hypothetical cues, including:

- Increases in Delta inflow
- Decreases in water temperature
- Changes in ambient light due to decreasing day lengths during late fall

Water temperatures and hydrodynamic indicator variables were plotted with historic salvage for the October-thru-January period and evaluated by eye (see attachment[1]). Evaluation of the resulting graphs revealed that an algorithm would be needed to identify where a salvage "event" actually occurs, since in all years there is a period of relatively modest salvage followed by one or more peaks. As discussed at the previous meeting, inflow alone is not a satisfactory predictor of salvage events. X2 position, which is considered a good indicator of delta smelt distribution, does not respond quickly enough to be a good predictor of salvage events. Drops in water temperature always precede salvage events, but such drops occur every year, so as a single environmental factor temperature is not an adequate predictor. However, a drop in water temperature, perhaps to some threshold value, followed by an increase in inflow should be evaluated as a predictor of salvage events.

[1] The reader is cautioned to pay close attention to the scale of the various graphs; also, cumulative salvage is denoted by blue circles in all graphics except for those depicting the average temperatures at Antioch, where cumulative salvage appears as red triangles.

The Working Group's next steps will be to refine the potential environmental triggers and guidelines and game them using historical salvage data. Adult delta smelt ride the tides to reach spawning habitats, so tide data could be added. An attempt must be made to define the amount and the extent of any potential curtailments. Curtailments would be defined in terms of Old River and Middle River flow targets, and the water costs of potential actions could be estimated. OR/MR flows allow for a certain amount of flexibility, as they can be achieved via reduced exports, increased SJR flow or various combinations of the two.

Potential scenarios to evaluate include:

- Export curtailment in response to an observed salvage event that triggers concern, i.e., business as usual
- A prescriptive curtailment, i.e., one beginning at a prescribed time and continuing for a prescribed period (more work would be needed)
- A curtailment triggered by an environmental predictor, e.g., temperature followed by flow as mentioned above

The same small subgroup will refine the analyses and report to the full Working Group at the next meeting.

On another topic, an evaluation of CDFG's Larval Survey sampling is needed. Thus far, the sampling has not collected very many larval delta smelt; its original intent was to evaluate gear types and sampling protocols, but last year it was subsumed by the POD effort in an attempt to determine larval distribution of species of concern. CDFG wishes to return to the original intent of the survey and use appropriate gears and deployment; however, the management questions that the survey is intended to address are unclear. If the question is when larvae become vulnerable to entrainment, it may be that this can be answered using a combination of data from spent adults, X2 and water temperatures. At a certain point, the 20-mm Survey is a more effective means of elucidating distribution. If the question is one of early detection so that actions can be taken to minimize entrainment, different gears and protocols may be needed. CDFG will submit a draft work plan to the Interagency Ecological Program.

Action Items:

1. Mike Chotkowski, Kevin Fleming, Matt Nobriga and Bruce Herbold will confer to refine the analyses, and will report back to the full Working Group at the next meeting.

Next Scheduled Meeting: Tuesday, October 10, 2006, at 2:00 pm in room W-1931 at the Cottage Way federal building.

One attachment

Submitted, VLP

Attachment

Figure 1. Delta smelt salvage by date, with dates represented as days after October 1.

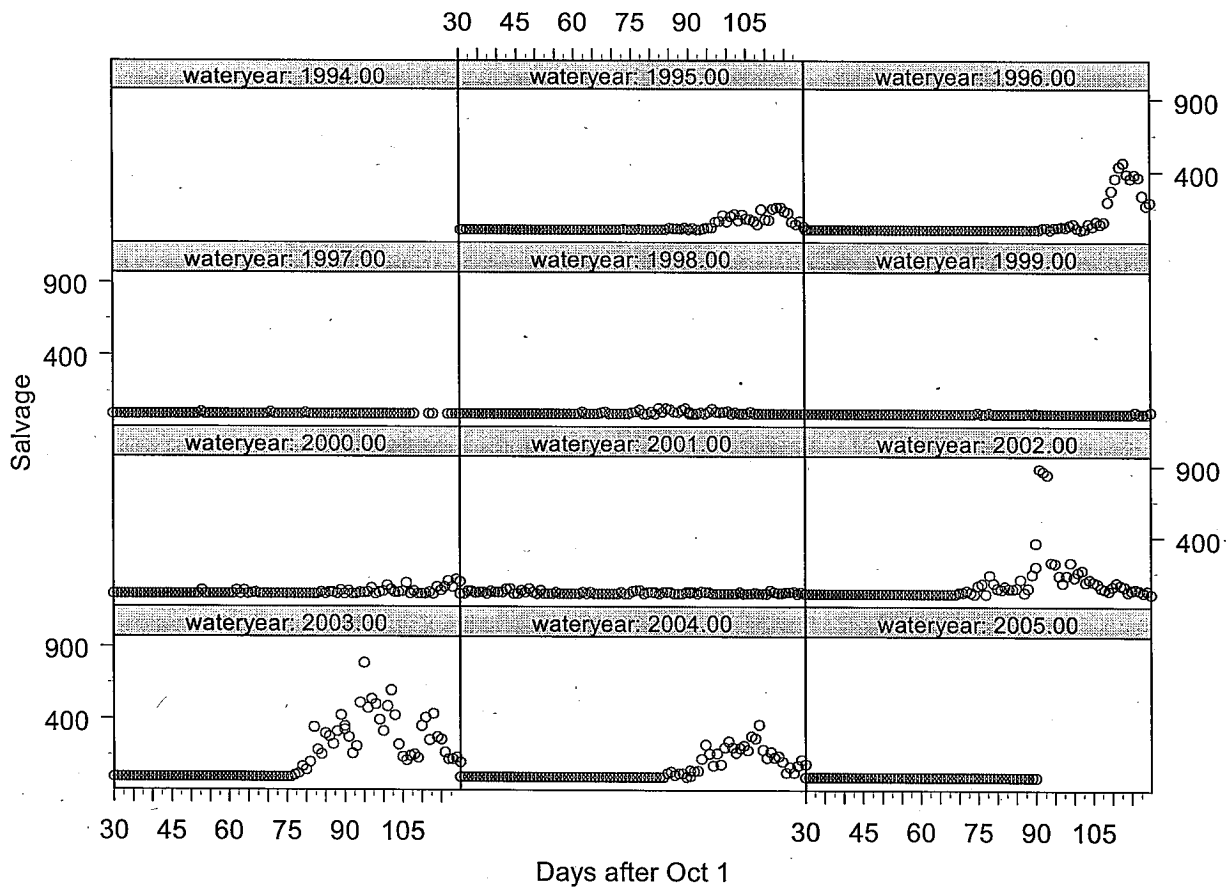


Figure 2. Cumulative delta smelt salvage with Delta inflow overlaid.

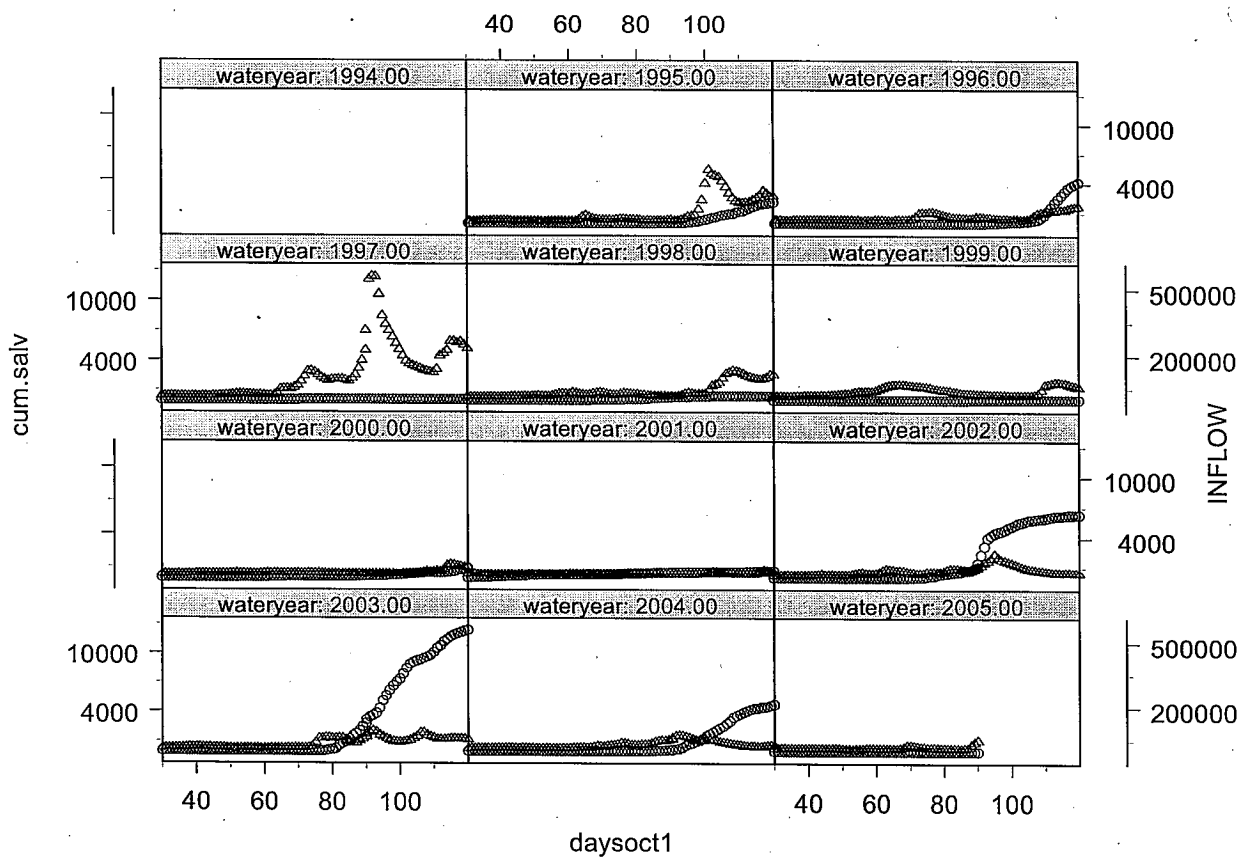


Figure 3. Cumulative delta smelt salvage with average X2 overlaid.

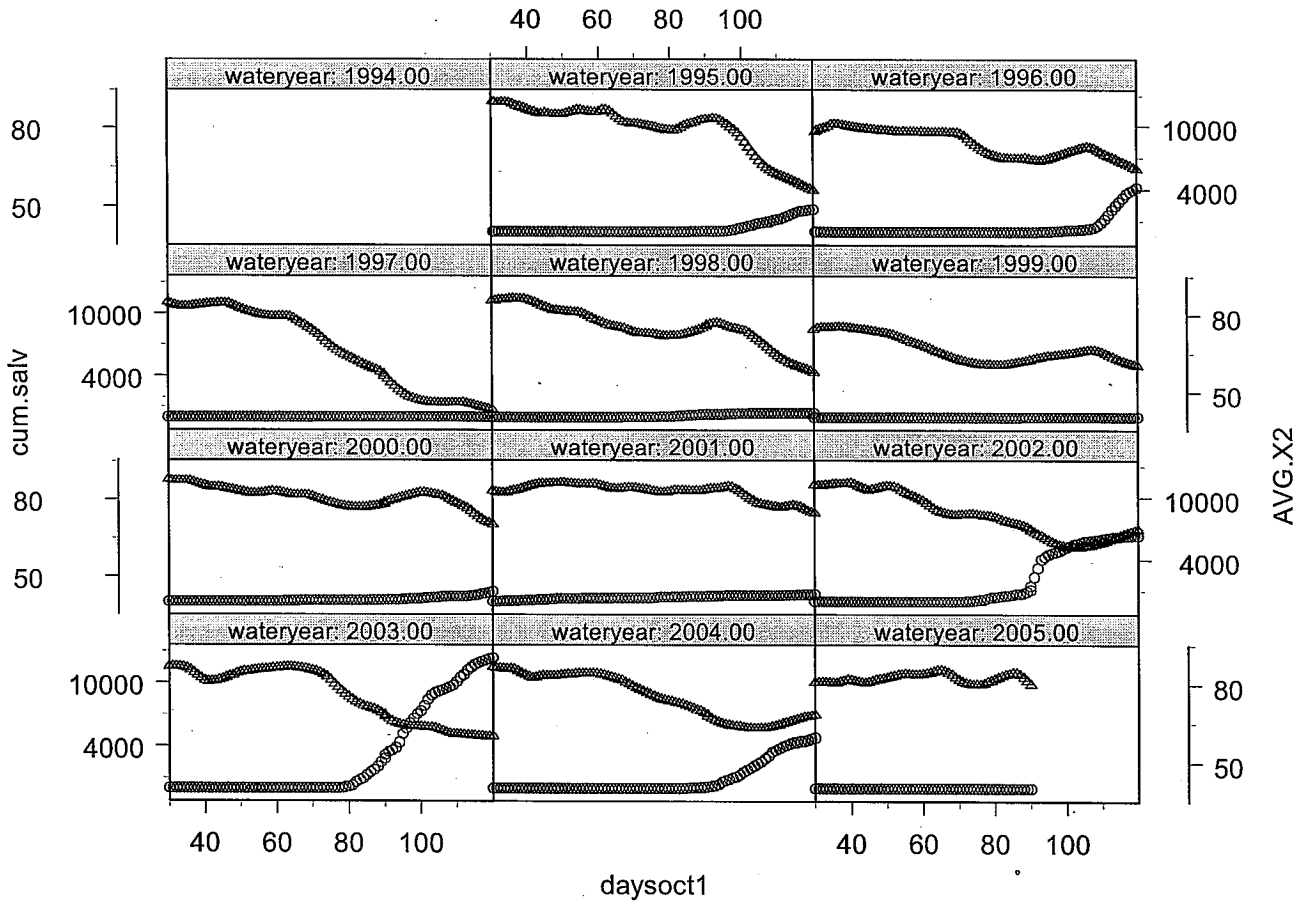


Figure 4. Cumulative delta smelt salvage with average water temperature at Antioch overlaid.

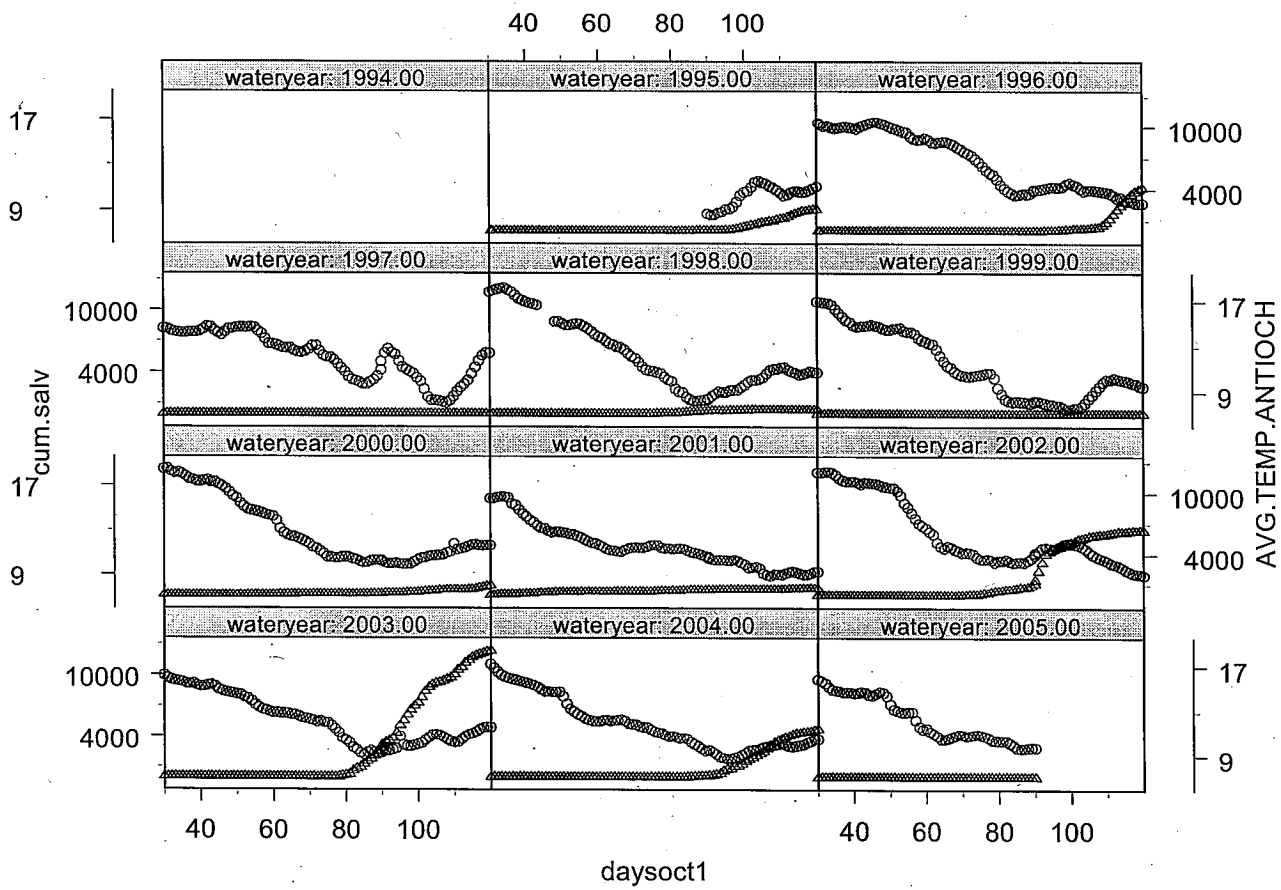


Figure 5. Cumulative delta smelt salvage with Sacramento River flow overlaid.

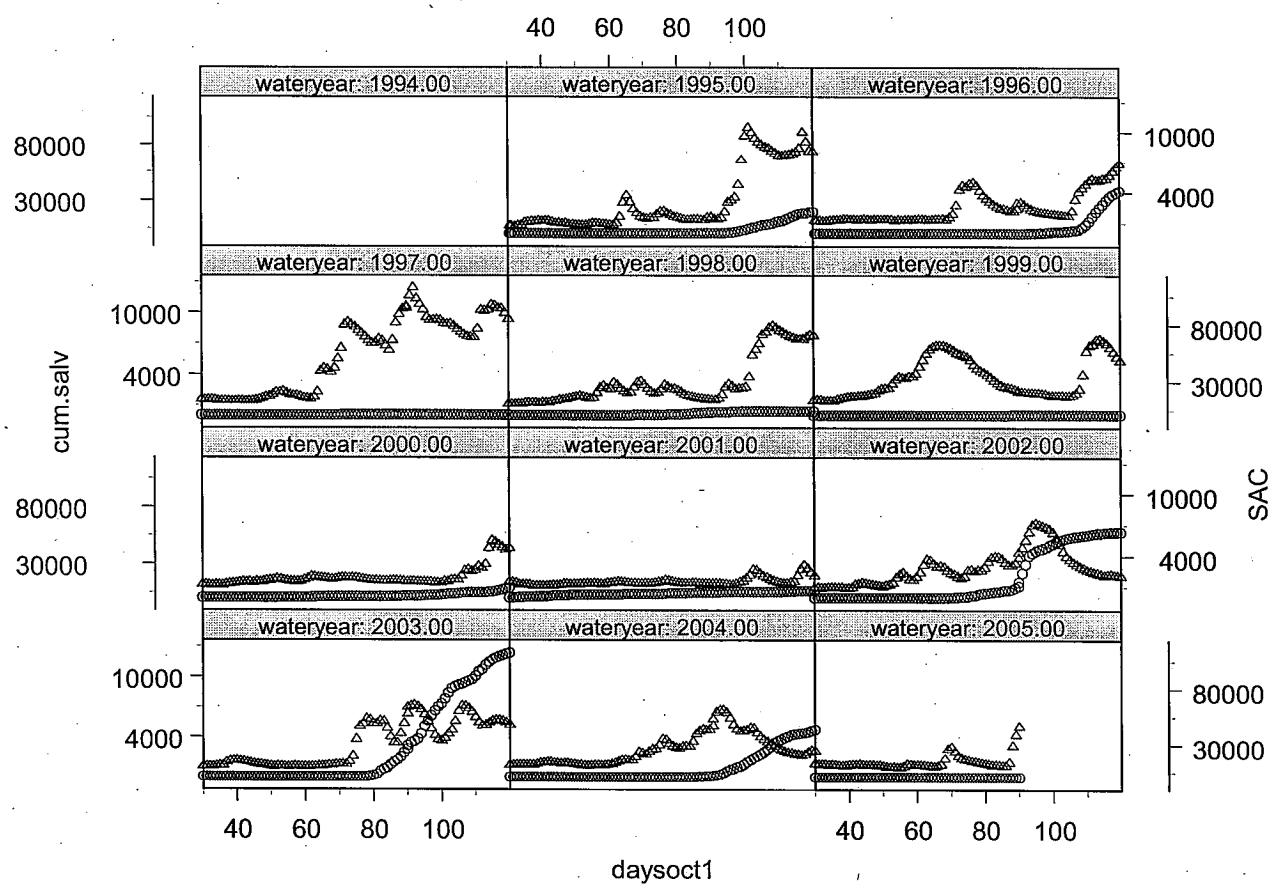


Figure 6. Cumulative delta smelt salvage with San Joaquin River flow overlaid.

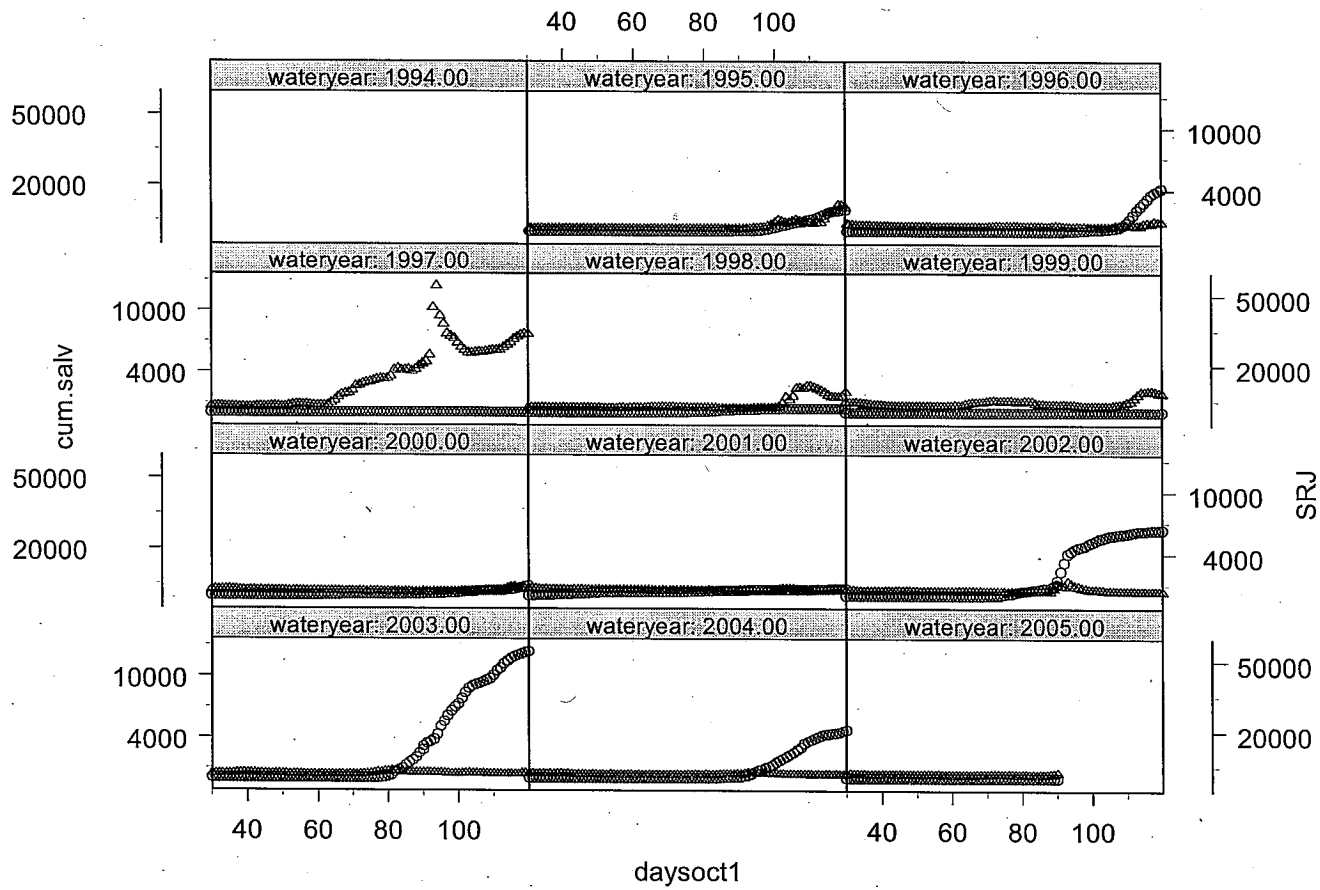
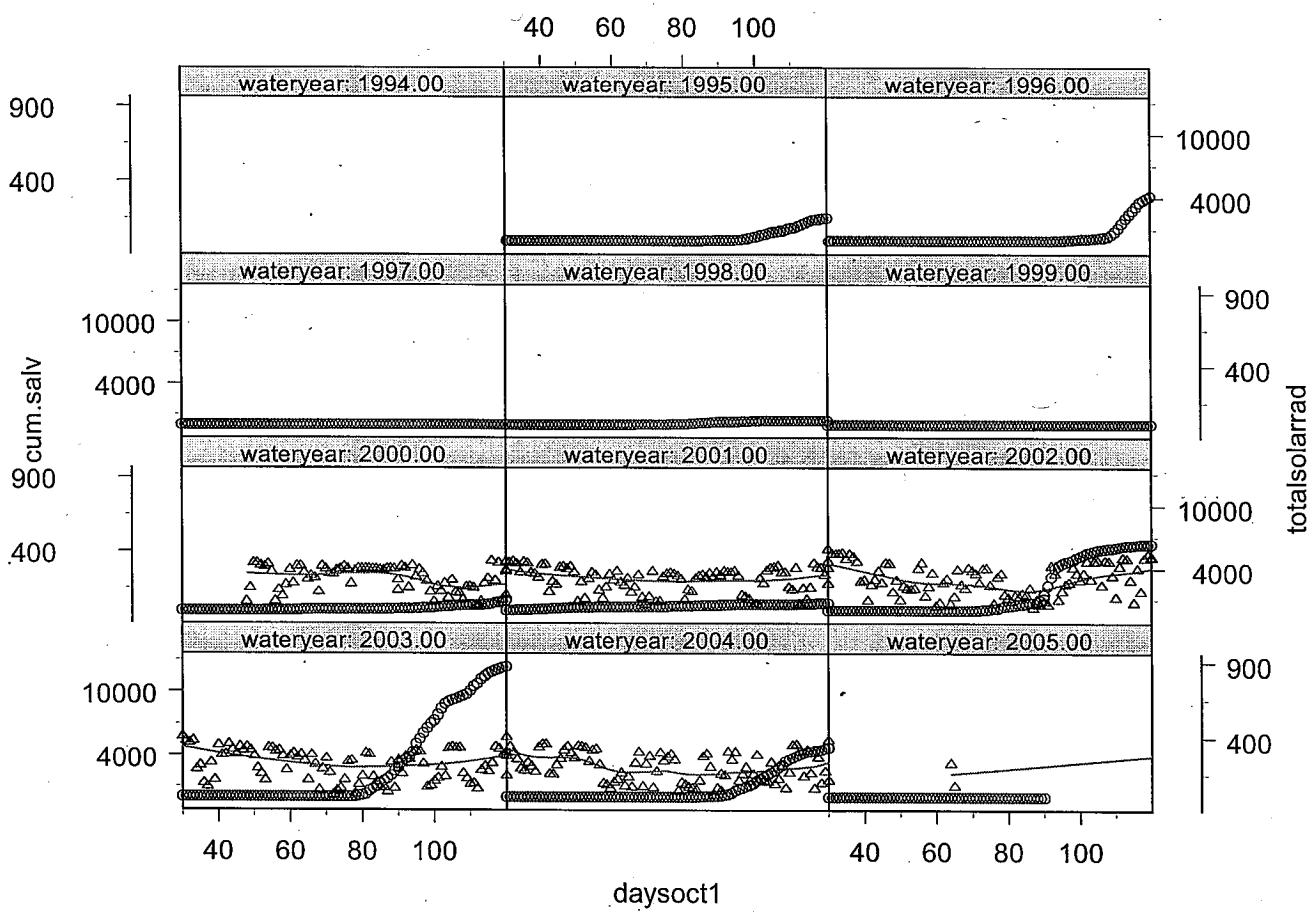


Figure 7. Cumulative delta smelt salvage with total daily solar radiation overlaid.



# Attachment 14-H

# EXHIBIT 9

Delta Smelt Working Group Meeting Notes

December 11, 2006

Participating: Gonzalo Castillo (USFWS), Mike Chotkowski (USBR), Kevin Fleming (CDFG), Lenny Grimaldo (CDWR), Tracy Hinojosa (CDWR), Ann Lubas-Williams (USBR), Matt Nobriga (CDWR), Ted Sommer (CDWR), Jim White (CDFG) and Victoria Poage (USFWS, convener and scribe)

For Discussion:

1. Revisit the preliminary recommendation for a winter action from the October 10 meeting
2. Future recommendations for spring South Delta barrier installation
3. Resources' POD Action Matrix and supporting documentation

Recommendation for WOMT: The Working Group had two recommendations for WOMT. These recommendations reflect conditions which the Working Group believes are likely to minimize salvage of pre-spawning adult delta smelt in winter and larval delta smelt in spring, but if high salvage occurs, then other actions may be warranted.

First, the Working Group finalized the preliminary recommendation from October 10 as follows:

- Implement a proactive winter action to address concerns about wintertime entrainment of adults during "first flush" conditions. It is unlikely that any action will be needed until after December 25th. Delta water temperatures have already dropped below $13^0$ C (compiled from data from Mossdale, Antioch and Rio Vista). Once the time of year and water temperature cues are appropriate for smelt migration to spawning areas, the Working Group may recommend the following: no more than seven days after Sacramento River flow at Freeport rises above 25,000 cfs for at least three days, increase flows in lower Old and Middle Rivers to at least -3500 cfs until February 15th.
- If no Sacramento River pulse above 25,000 cfs occurs by January 15th then Old and Middle River flows should be moderated to a range of -5000 cfs to -3500 cfs until February 15th.
- If flows on the Sacramento River are above 25,000 cfs prior to Dec 25th, and remain above 25,000 cfs through Feb 15th, the Working Group does not anticipate requesting operational changes. However, actions may be considered if Freeport flows increase but are not sustained above 25,000 cfs or if high salvage events occur.

The Working Group will consider and/or generate additional analyses of existing data and continue to monitor conditions in the Delta and survey sampling results to determine whether further refinements to the recommendation are needed.

The second recommendation is to forego installation of the spring Head-of-Old River Barrier and to postpone installation and operation of the agricultural barriers until June 1.

Meeting Notes:

1. The Delta Smelt Working Group revisited the preliminary recommendation for a winter action made at its October 10 meeting. The Working Group retained its original "first flush" conceptual model, which assumes, based on an examination of salvage data and numerous environmental variables, that adult delta smelt movement up the estuary (which increases vulnerability to entrainment) follows decreases in Delta water temperature and increases in Sacramento River flow. The Working Group retained the temperature criterion of less than 13$^0$C at Mossdale, Antioch and Rio Vista and Sacramento River flow criterion of exceeding 25,000 cfs for at least three days as triggers for a winter action. It was noted that the EWA Technical Panel and others have asked the Working Group why, if we accepted analyses presented by Pete Smith, we did not recommend setting net flows in Old and Middle Rivers to zero (cfs) to better protect pre-spawning adults. The Working Group believes that while eliminating net upstream OR/MR flow likely would be better for delta smelt, operating to this target would be prohibitively expensive, and that significant protection could be achieved with flows of -3500 cfs. DWR staff have derived estimates of the water costs of the potential actions in the Resources Agency POD Action Matrix and found that the proposed winter action could consume all available environmental water, leaving no assets for spring actions for larvae or juveniles. The Working Group discussed assessing the expected benefit of alternative OR/MR flows for adult delta smelt, given that there are two key issues: (1) the rate of the flow reduction and (2) the duration of the flow reduction. In relative terms, contingency tables of flow versus duration could look something like this:

Adults

| | 1 week | 4 weeks |
|---|---|---|
| 0 cfs | Better | Best |
| -3500 cfs | Worse | Not So Bad |

Juveniles

| | 1 week | 4 weeks |
|---|---|---|
| 0 cfs | Not So Bad | Best |
| -3500 cfs | Worse | Better |

The Working Group discussed restructuring the recommendation so as to gain some of the expected benefit of zero cfs, if only for a short period of time, by prescribing zero cfs for two weeks, followed by -2000 cfs for 1 or two weeks, followed by -3500 cfs for one or two weeks, using the same criteria of temperature and flow to trigger an action. However, this flow regime would not alleviate the potential shortfall in available environmental water assets, so it was not added to the recommendation.

The Working Group decided to adopt its preliminary recommendation of October 10 as a formal recommendation for a winter action. It was noted that "first flush" conditions should not take anyone by surprise; Delta water temperatures will likely drop gradually, and significant increases in Sacramento River flows would likely become apparent three to five days before Freeport flows trigger an action. However, the Working Group believed that additional analyses of the relationship of salvage to OR/MR flows and of days post-flush to first salvage would be informative. Two families of recommendations, one for adults and one for juveniles, could conceivably be generated via additional analyses of salvage in relation to OR/MR flow. Some of this work may already have

been undertaken by others; the status of this work should be clarified and remaining analyses undertaken as appropriate.

2. Recent PTM modeling (see October 30 meeting notes) indicated that the South Delta barriers increase particle entrainment risk from the central Delta. The Working Group recommends against the installation of the spring Head-of-Old River barrier and postponement of the installation and operation of the agricultural barriers until June 1.

Discussion of the first two agenda items did not leave sufficient time for discussion of the supporting documentation for Resources' POD Action Matrix.

Submitted,
VLP

Attachment 14-I

# EXHIBIT 10

Delta Smelt Working Group Meeting Minutes

October 10, 2006

Participating: Gonzalo Castillo (USFWS), Mike Chotkowski (USBR), Kevin Fleming (CDFG), Lenny Grimaldo (CDWR), Bruce Herbold (USEPA), Tracy Hinojosa (CDWR), Peter Johnsen (USFWS), Ann Lubas-Williams (USBR), Matt Nobriga (CDWR), Ted Sommer (CDWR), Jim White (CDFG) and Victoria Poage (USFWS, convener and scribe)

For Discussion:
1. CDFG's action plan matrix
2. Refined analyses of data pertinent to winter salvage events (triggering variables)
3. Parameters for PTM modeling of CCF gate ops

Recommendation for WOMT:
The Working Group made a preliminary recommendation to implement a proactive winter action to address concerns about wintertime entrainment of adults during "first flush" conditions. No action will likely be needed until after December 25th and after Delta water temperatures drop below $13^0$ C (compiled from data from Mossdale, Antioch and Rio Vista). Once time and temperatures are appropriate for smelt spawning movements, Sacramento River flow at Freeport increases above 25,000 cfs should trigger operational changes to achieve flows in lower Old and Middle Rivers no more negative than -3500 cfs. If no Sacramento River pulse above 25,000 cfs occurs by January 15th then Old and Middle River flows should be moderated as much as possible until February 15th. This recommendation reflects conditions which the Working Group believes are likely to minimize salvage of pre-spawning adult delta smelt, but if high salvage occurs other actions may be warranted.

If flows on the Sacramento River are above 25,000 cfs prior to Dec 25th, and remain above 25,000 cfs through Feb 15th, no action should be necessary.

Salvage of adults or other conditions suggesting that adults are spawning in the South Delta are an indicator that springtime actions may also be beneficial. If salvage is low and flows in Old and Middle Rivers are not strongly negative in January and February, then springtime actions might not be warranted.

Minutes:
The second sampling period of the Fall Mid-Water Trawl survey is underway this week. No information was available.

CDFG has been asked to compile a supplement to the POD Action Plan that outlines any new actions that could potentially be taken to protect delta smelt. Kevin Fleming presented a draft document with separate potential actions for winter and spring (see attachment 1). The emphasis was on actions that could be implemented at the SWP. The first trigger would come with the Recovery Index, as before, but DFG proposed that if the

index is less than 74 and the net flow at Old and Middle Rivers is more negative than -5000 cfs, flows be increased so that net Old and Middle river flows are no more negative than -5000 cfs, either by reducing exports or increasing San Joaquin River flow. DFG proposed changing the level of salvage concern from reaching the 50th percentile of the ratio of salvage to the recovery index to reaching the 25th percentile of the ratio, and making both percentiles triggers for export reductions or increases in SJR flow. After reviewing the graphic of Old and Middle River flow plotted against salvage (attachment 2), the Working Group recommended that OR/MR flows be increased further, to no more negative than -3500 cfs. Although the graphic depicts a linear relationship, the Working Group discussed the possibility that it is likely more sigmoidal, with a threshold level of effect followed by a steep upward curve. The Working Group noted that some of the weaknesses of the DFG plan included the potential to exhaust all EWA and B2 assets in winter, leaving nothing in reserve for spring actions, and that the document specifies no magnitude or duration for the proposed export cuts/flow increases. The Working Group noted that if a winter action is triggered by a salvage event, indicating adult delta smelt are (or at least were) present in the southern Delta and will be spawning there, then the likelihood that a spring action would be needed is greater than if an action is triggered only by environmental factors. However, if the adult salvage concern level is not reached, a spring action may not be needed. These recommendations notwithstanding, decisions to implement the action would best be made in real-time, as circumstances dictate. Spring actions do not yet include a flow trigger; this needs further discussion, and may depend upon real-time conditions and the results of PTM modeling. Spring actions also include modifications to Clifton Court Forebay intake gate operations. Following the discussion, changes will be made to the document which will be circulated for further review and comment by the Working Group and then forwarded to DFG management for final review.

The Working Group continued its August 30 and September 26 discussions of the environmental factors that correspond to the onset or sudden increases in salvage of pre-spawning adult delta smelt. Preliminary analyses indicate that a drop in water temperature to about $13^0$ C followed by an increase in Delta inflow may be a good predictor of adult salvage. More work is needed to refine these potential environmental triggers; however, the Working Group made the following preliminary recommendation:

1. action triggered by environmental factors (proactive mode)
    - when Delta water temperatures reach $13^0$ C and Delta inflow increases to 25,000 cfs or greater, increase the net OR/MR flow to no more negative than -3500 cfs
    - if no Sacramento River pulse above 25,000 cfs occurs by January 15th then Old and Middle River flows should be moderated as much as possible until February 15th.
2. action triggered by salvage (reactive mode)
    - when the adult concern level is reached, be it the 25th or the 50th percentile of the ratio, respond as per the DSRAM

As always, the Working Group believes that reacting to a salvage event as it occurred would be far less effective than anticipating a salvage event; the former likely defers or extends salvage in time, whereas the latter is intended to avoid and/or minimize salvage.

A spring action could include reoperation of the CCF intake gates and modification of the schedule by which South Delta barriers (not just the HORB) are installed. Analysis of CCF gate operations and screening efficiency indicate that there may be a diel effect of pumping, and that decreases in approach velocities lead to increases in salvage, likely because of increased efficiency of the screens. Analysis of barrier operations indicates that all barriers, not just the HORB, affect South Delta circulation and particle fate. How this information may be used to reduce impacts to delta smelt warrants further discussion.

The Working Group has for some time been interested in Particle Tracking Modeling of the effects of CCF intake gate operations. Reoperation of the CCF intake gates could even out channel velocities, export pumping and approach velocities and therefore affect salvage. The Working Group proposed that the following PTM runs be performed:

| | Barriers in: | | Barriers out: | |
|---|---|---|---|---|
| SJR | 4500 | 7000 | 4500 | 7000 |
| Exports | 1500 comb. | 3000 comb. | 1500 comb. | 3000 comb. |
| Gates | Fully Open | Fully Open | Std. Ops | Std. Ops |

The PTM would be run for VAMP-like conditions from April 15 – May 15. Particles would be released at 20-mm stations 815, 902 and 910, as in the runs performed last year. Rather than the traditional bar chart output, the Working Group requested a cumulative output of particle fates. Holding Sacramento River flows constant, potentially in the range of 20-30,000 cfs, for both San Joaquin flow values would avoid introducing a confounding factor. However, it may be more realistic to match historic SR flows to historic SJR flows.

Action Items:

1. Mike Chotkowski will work on refining the winter salvage trigger analyses.
2. DWR modeling staff will perform the requested PTM runs.

Next Scheduled Meeting: Not yet scheduled.

Attachments: 2

Submitted,

VLP

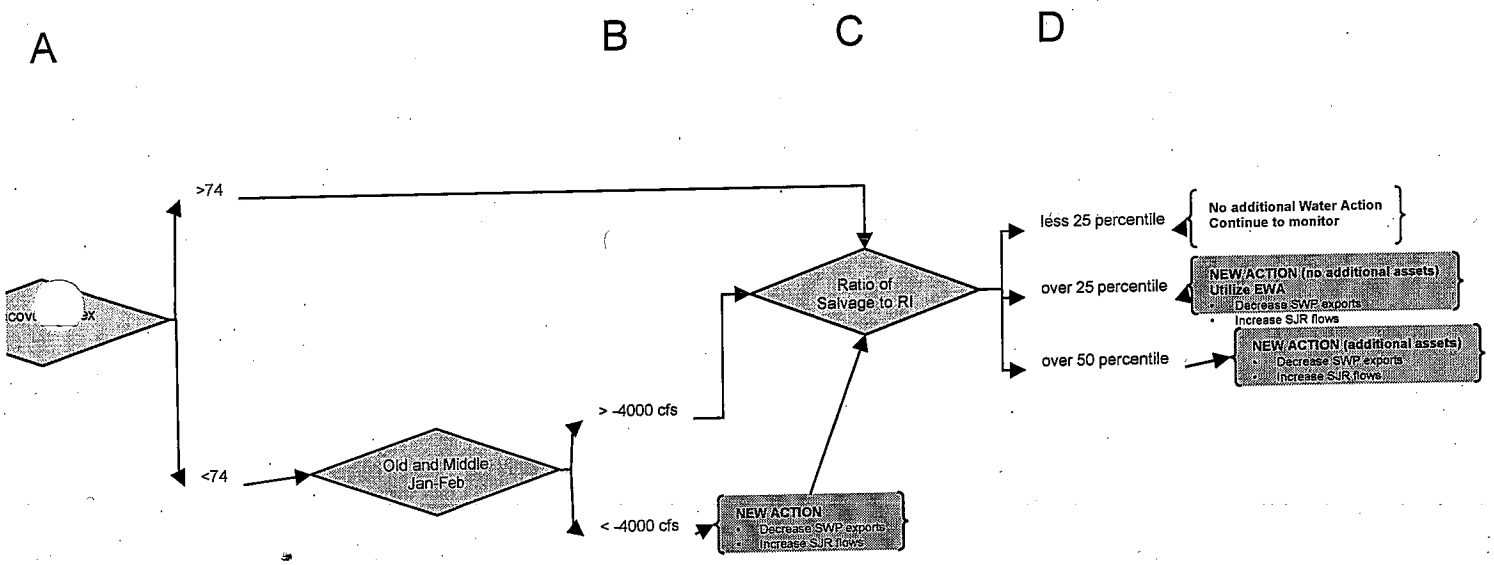
nent 1. DFG Draft Action Plan document

## inter Action – DRAFT for discussion only

### ɜduce entrainment of POD fish (delta smelt, longfin smelt and striped bass)

*lodify Old and Middle River flows (pre-emptive)*

*'educe salvage (reactionary)*



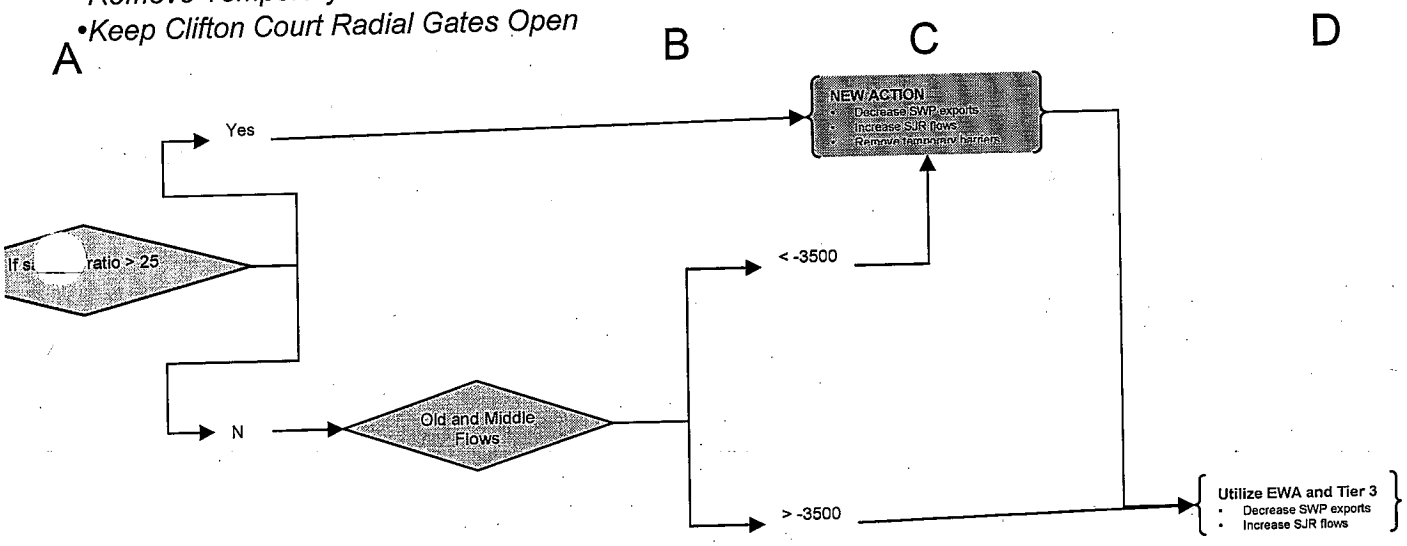

*Recovery Index is based upon FMWT and will be available by mid October. The RI of 74 represents the median for all years. From the RI the salvage concern levels is calculated. This algorithm for the concern level is found in the 2005 USFWS OCAP BO.*
*January and February combined Old and Middle River flows should be projected based upon model runs with both current and projected operations. The -4000 cfs criterion is only a first approximation based upon a visual inspection of the graphs prepared by Pete Smith, USGS. The actual target criterion will require further input from DSWG an other Agency staff.*
*The amount and timing of the new action to reduce negative flows will require further input from DSWG an other Agency staff. It will likely determined by a combination of spawning migration cues (outflow and temperature) as well as historic patterns of salvage events.*
*This is a modification of the current DSRAM with the inclusion of a more protective criterion for concern. Given a low RI the differences in salvage numbers between 25 and 50 percentile is not anticipated to be great and the length of time between hitting the 25 and 50 percentile will be short. Therefore, additional water assets need to be identified prior to the need and readied for implementation.*

## Early Spring Action – DRAFT for discussion only

## Reduce entrainment of POD fish (delta smelt, longfin smelt and striped bass)

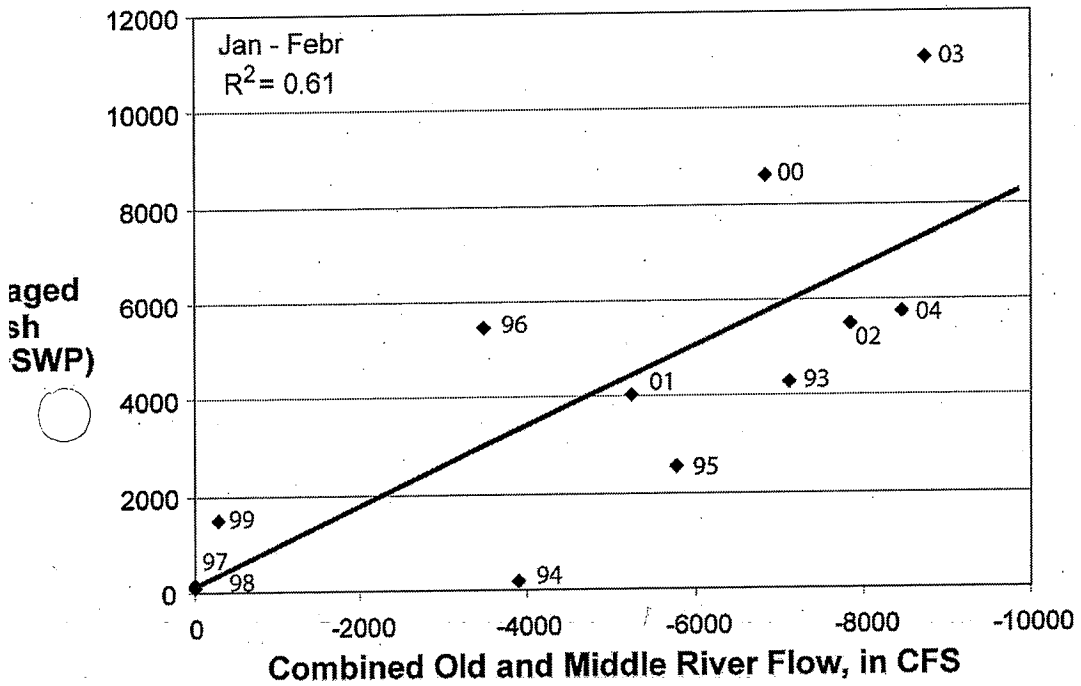
*Modify delta hydrology during early delta smelt early larval stage*

- *Additional assets (SJR)*
- *Reduced SWP exports*
- *Remove Temporary Barriers*
- *Keep Clifton Court Radial Gates Open*




- *If there was a need for winter protection of the adults pre-spawn, there will be a need to protect the larvae.*
- *Relationship between early flows and subsequent delta smelt distribution. Based upon 20MM Survey "centroid" distribution, the higher the early flows the further downstream the resulting smelt distribution.*
- *The amount and timing of the new action to reduce entrainment will require further input from DSWG and Agency staff. It will likely determined by a spawning cues (temperature) as well as historic patterns of salvage events.*
- *This is would include a pre-VAMP use of EWA assets. It may turn out that the only time that the radial gates can be left open is during this pre-VAMP/VAMP period, in which case this is where that particular new action will be used.*

nent 2.




Pete Smith, USGS

# Attachment 14-J

# EXHIBIT 11

RONALD J. TENPAS, Acting Assistant Attorney General

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Attorneys for the Federal Defendants

**UNITED STATES DISTRICT COURT**
**FOR THE EASTERN DISTRICT OF CALIFORNIA**
**FRESNO DIVISION**

| | |
|---|---|
| NATURAL RESOURCES DEFENSE COUNCIL, et al.,<br><br>Plaintiffs,<br><br>v.<br><br>DIRK KEMPTHORNE, et al.,<br><br>Defendants. | Case No.: 1:05-CV-01207 OWW LJO<br><br>**DECLARATION OF BRUCE OPPENHEIM** |

I, Bruce F. Oppenheim, hereby declare as follows:

1. I am a Fishery Biologist for the National Marine Fisheries Service (NMFS), Southwest Region, Sacramento Area Office and have been employed by the NMFS over 7 years. In my capacity as a fishery biologist I have been responsible for implementing the Federal Endangered Species Act (ESA) within the Sacramento and San Joaquin River Basins (California's Central Valley). I have worked on various ESA section 7 consultations including the Central Valley Project (CVP) and State Water Project (SWP) Operations, Criteria, and Plan (OCAP) for the past 7 years. I have been involved with CVP and SWP operations throughout my career as the NMFS representative on the Water Operations Management Team, the Data Analysis Team, the B2 Interagency Team, the Environmental Water Account Team and the Sacramento River

Temperature Task Group. All of these teams are integrated into the adaptive management process described in OCAP. Previously, I was employed by the U.S. Fish and Wildlife Service in the Stockton Field Office (1999-2000), and the Arcata Field Office (1990-1999) where I was involved in salmon monitoring on the Klamath and Trinity Rivers.

2. There are four anadromous fish species in the Sacramento River/San Joaquin River system that are listed under the ESA over which the NMFS has jurisdiction: winter run Chinook salmon, spring run Chinook salmon, the Central Valley steelhead Distinct Population Segment (DPS), and the southern DPS of North American green sturgeon. In addition, fall run Chinook salmon are present in this system. While fall run Chinook salmon are not listed under the ESA, the federal actions affecting fall run Chinook salmon habitat are subject to provisions of the Magnuson-Stevens Fishery Conservation and Management Act.

3. The continued existence of these anadromous species depend in large part on decisions made by federal and state project operators that control the releases from upstream reservoirs. Decisions made to manage habitat conditions for delta smelt, a resident pelagic fish in the Sacramento-San Joaquin Delta (Delta), have direct consequences for other species that use the same Delta habitat, including the four fish species under NMFS ESA jurisdiction. The system of dams and water conveyance structures included in the CVP and SWP block access to a significant portion of historical habitat limiting the available habitat for spawning and rearing. Modification of planned releases of stored water in project reservoirs affects downstream flows and the ability to manage water temperatures for anadromous fish. A limited amount of cold water exists in project reservoirs and must be judiciously allocated during critical periods (spawning and egg incubation).

4. Adequate attraction flows in the fall are necessary to overcome the adverse effects of poor water quality and low flow conditions in the San Joaquin River for fall run Chinook salmon and steelhead. Water usually reserved for fall actions was purchased on the Stanislaus and Merced Rivers and released this spring in order to decrease reverse flows in the Delta.

5. Over the past several weeks, flows have fluctuated in the Stanislaus River. Historically, at the end the 4-week pulse of flows and reduced export pumping associated with the Vernalis

Adaptive Management Plan (VAMP), flows are ramped down on the Stanislaus River to queue remaining salmonid species (including juvenile fall run Chinook salmon and listed steelhead) to outmigrate before water temperatures in the Delta reach lethal levels. Recently, when the U.S. Bureau of Reclamation (Reclamation) contacted NMFS and inquired about raising flows on the Stanislaus River to increase Delta inflow from the San Joaquin River watershed (in order to protect delta smelt by minimizing or avoiding reverse flows in Old and Middle Rivers), NMFS did not oppose the action. However, NMFS encouraged Reclamation to ramp flows downward as soon as possible, to avoid potential impacts to salmonid species. NMFS intends to continue to work with Reclamation to ensure continued protection of salmonid species.

6. NMFS is concerned that the proposed remedial actions for delta smelt may reduce fall attraction flows in the San Joaquin River system, and the ability to meet water temperature requirements in the Sacramento River basin next spring and summer. Water temperature criteria for ESA listed fish species are non-discretionary conditions described in the NMFS 2004 OCAP biological opinion. Flow and temperature standards are considered part of the baseline operations required by the State Water Resource Control Board Decision Order 90-05 for the Sacramento River, and Water Right Decision 1641 for the Delta. The operations of the CVP are linked together, therefore, the use of environmental water after VAMP on the San Joaquin River may have consequences later in the year on the Sacramento River.

7. The 90 percent exceedence forecast for May 2007, shows the End-of-September (EOS) carry-over storage requirement in Shasta Reservoir will be about 1.902 million acre feet (MAF). This required storage level is considered necessary to protect the cold water pool available for winter run Chinook salmon spawning below Keswick Dam. Any additional releases from Shasta Reservoir could reduce EOS storage below the 1.9 MAF criteria and limit the ability to control water temperatures in upstream spawning areas. In addition, higher releases from Folsom Dam on the American River for delta smelt may reduce the ability to manage water temperatures for Central Valley steelhead and reduce the cold water available for commercially valuable fall run Chinook salmon spawning in November. This year (2007) is considered a "dry" water year, therefore, reservoir storage levels should be conserved in case of a subsequent "dry" or "critical"

year in 2008.

8. Remedial actions for delta smelt (such as export reductions and positive Old and Middle River flows) will have positive effects on juvenile salmonids through reduced entrainment at the Delta pumps and higher survival rates. However, some proposed actions such as opening the Delta Cross Channel gates early, and not installing the Head of Old River Barrier would reduce survival of salmonids, while being of questionable significance to delta smelt. The actions taken for delta smelt need to be balanced against the impacts on other listed fish species.

This declaration is made pursuant to 28 U.S.C. 1746. I declare under perjury that the foregoing is true and correct to the best of my current knowledge.

Respectfully submitted this 15th day of June, 2007, in Sacramento, California.

Bruce F. Oppenheim

# Attachment 14-K

# EXHIBIT 12

RONALD J. TENPAS, Acting Assistant Attorney General

JEAN E. WILLIAMS, Section Chief
KEITH W. RIZZARDI, Trial Attorney (Fla. Bar No. 38237)
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Attorneys for the Federal Defendants

**UNITED STATES DISTRICT COURT**
**EASTERN DISTRICT OF CALIFORNIA**

| | |
|---|---|
| NATURAL RESOURCES DEFENSE COUNCIL, CALIFORNIA TROUT, BAYKEEPER & ITS DELTAKEEPER CHAPTER, FRIENDS OF THE RIVER, and THE BAY INSTITUTE, all non-profit organizations,<br><br>Plaintiffs,<br>v.<br><br>DIRK KEMPTHORNE, in his official capacity as Secretary of the Interior, and H. DALE HALL, in his official capacity as Director of the U.S. Fish and Wildlife Service,<br><br>Defendants.<br><br>SAN LUIS & DELTA MENDOTA WATER AUTHORITY, WESTLANDS WATER DISTRICT, CALIFORNIA FARM BUREAU FEDERATION, GLENN-COLUSA IRRIGATION DISTRICT, et al., CALIFORNIA DEPARTMENT OF WATER RESOURCES, STATE WATER CONTRACTORS; and KERN COUNTY WATER AGENCY.<br><br>Intervenors/Defendants. | Case No.: 05-CV-01207 OWW LJO<br><br>**DECLARATION OF RONALD MILLIGAN** |

I, Ronald Milligan, declare as follows:

1. I am the Manager of the Central Valley Operations (CVO) Office of the United States Bureau of Reclamation (Reclamation), Mid-Pacific Region. In my capacity as CVO Manager, I have responsibility for the day to day operations of the Central Valley Project (CVP). I have held this position since November, 2004.

2. CVP is currently pumping at 3500cfs from Jones Pumping Plant (Jones). Since May 30, there has been estimated salvage of 61 delta smelt (5 actual observed and one incidental observation) at Jones.

3. Water temperatures in the south delta have been have ranged from 20.4°C on May 23 to 25°C on June 18 for the three station average. On Monday, June 18, the three station average reached 25°C for the 1 pm to 6 pm period. Attachment 1 to this declaration shows the data collected from the monitoring stations for May 22, 2007 to June 20, 2007.

4. To date, Reclamation has spent approximately $5.2 million to augment flows on the San Joaquin River to improve Old and Middle River Flows. Releases from the Merced River (approximately 15,000acre feet in total releases) continue to reach Vernalis and should continue through the Delta for the remainder of this week. Reclamation also purchased approximately 20,000 acre-feet of water on the Stanislaus River, which was released in May and June. Reclamation did not seek further releases on the Stanislaus in order to maintain sufficient storage to provide fall flows for salmon, and to cue any salmon or steelhead remaining in the Stanislaus to move into the Delta before temperatures in the Delta reached lethal limits.

5. Current tidal projections should significantly improve Old and Middle River flows this week.

6. Reclamation operates two reservoirs in the San Joaquin watershed, Friant Dam on the San Joaquin River and New Melones on the Stanislaus River. Friant is hydrologically isolated upstream from the confluence of the Merced River in all but the wettest of years, and operations of Friant Dam are subject to a court approved settlement in the matter of Natural Resources Defense Council, et al. v. Kirk Rodgers, et al., Civ. No. S-88-1658 LKK/GGH (E.D. Cal.).

7. Reclamation operates New Melones Reservoir to meet obligations to senior water rights holders, instream fishery flow in accordance with a 1987 agreement with the Department of Fish and Game, water quality and flow criteria at Vernalis as specified in Water Rights Decision D-1641, water dedicated under Central Valley Project Improvement Act Section

3406(b)(2), and project needs of the East Side Division CVP contractors. There is no additional water available for out of basin releases from New Melones Reservoir and releasing additional water would impact Reclamation's ability to meet its water obligations from New Melones Reservoir this year and into future years.

8. CVP demands for water from contractors are currently being met through a combination of pumping at Jones and withdrawal of water from San Luis Reservoir. Withdrawal of storage from San Luis Reservoir is still limited to 2 feet per day to protect from sloughing of the dam face. As the reservoir lowers the maximum withdrawal rate produces less supply.

9. Given warm weather and maturing crops, current demands require pumping levels greater than the pumping that occurred on June 17 and 18, which was approximately 2500cfs at Jones and 500 cfs at Banks Pumping Plant (Banks), a State Water Project (SWP) facility. Even at these rates water levels in O'Neill Forebay were critically low for several days. Supply interruption caused by low O'Neill storage was narrowly averted this last weekend. Such an interruption would result in reduced deliveries to SWP contractors south of Dos Amigos pumping plant and could take up to 9 hours to restore full deliveries to the Delta Mendota Canal.

10. Additional pumping is needed to avoid excessive drawdown of San Luis Reservoir and eventual allocation reductions caused by very low water levels in San Luis Reservoir. Failure to increase pumping will also likely result in reduced water quality for municipal

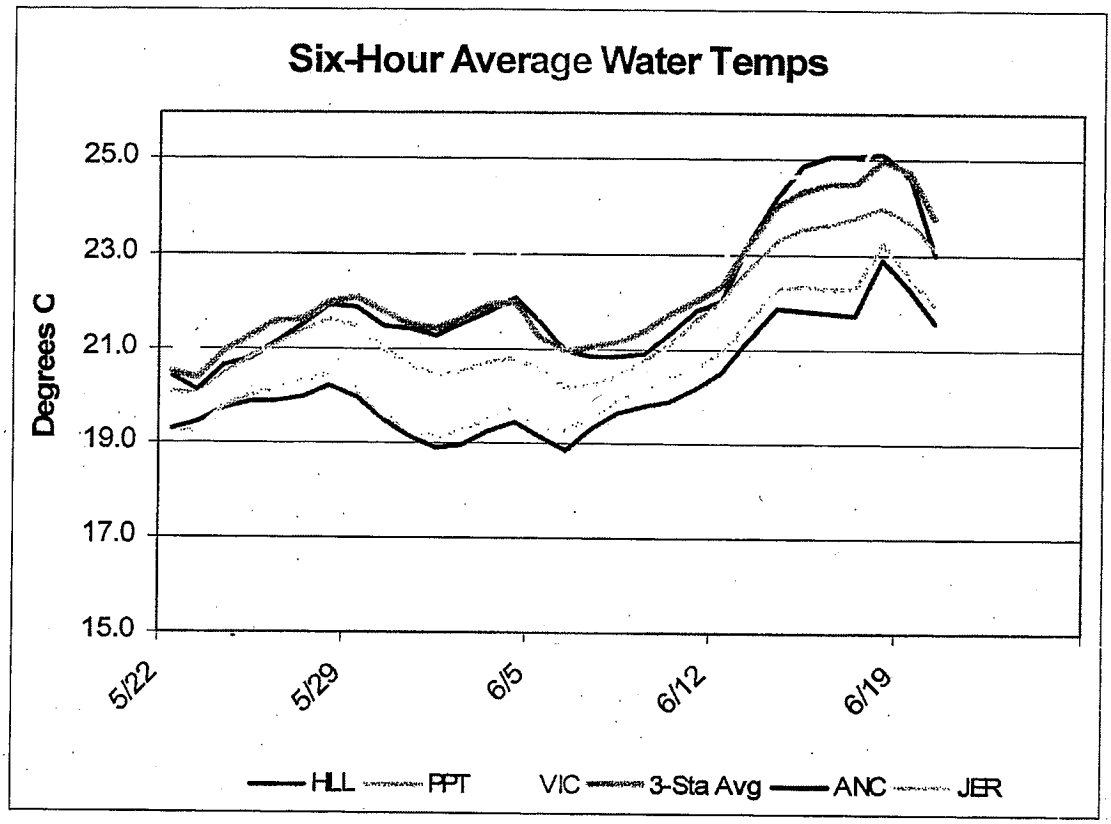
contractors in the San Felipe Division who receive water from San Luis Reservoir when the reservoir level reaches its lowest point in September (low-point).

I declare under penalty of perjury under the laws of the State of California and the United States, that the foregoing is true and correct.

Dated this 21th day of June, 2007.

Ronald Milligan
Manager, Central Valley Operations Office,
Mid- Pacific Region, U.S. Bureau of Reclamation

# Attachment 1


Six-Hour Average Water Temps
Degrees C
25.0
23.0
21.0
19.0
17.0
15.0
5/22
5/29
6/5
6/12
6/19
HLL
PPT
VIC
3-Sta Avg
ANC
JER

| Date | HLL | PPT | VIC | 3-Station Average | ANC | JER |
|---|---|---|---|---|---|---|
| 5/22/2007 | 20.4 | 20.1 | 21.1 | 20.5 | 19.3 | 19.2 |
| 5/23/2007 | 20.1 | 20.0 | 21.0 | 20.4 | 19.4 | 19.3 |
| 5/24/2007 | 20.6 | 20.5 | 21.8 | 21.0 | 19.7 | 19.8 |
| 5/25/2007 | 20.8 | 20.9 | 22.2 | 21.3 | 19.9 | 20.0 |
| 5/26/2007 | 21.1 | 21.1 | 22.5 | 21.6 | 19.9 | 20.1 |
| 5/27/2007 | 21.6 | 21.4 | 22.0 | 21.7 | 20.0 | 20.3 |
| 5/28/2007 | 21.9 | 21.6 | 22.4 | 22.0 | 20.2 | 20.5 |
| 5/29/2007 | 21.9 | 21.5 | 22.8 | 22.1 | 20.0 | 20.1 |
| 5/30/2007 | 21.5 | 21.0 | 22.9 | 21.8 | 19.5 | 19.6 |
| 5/31/2007 | 21.4 | 20.7 | 22.5 | 21.5 | 19.1 | 19.3 |
| 6/1/2007 | 21.3 | 20.4 | 22.5 | 21.4 | 18.9 | 19.1 |
| 6/2/2007 | 21.5 | 20.5 | 22.9 | 21.6 | 19.0 | 19.3 |
| 6/3/2007 | 21.8 | 20.7 | 23.3 | 21.9 | 19.2 | 19.5 |
| 6/4/2007 | 22.1 | 20.8 | 23.1 | 22.0 | 19.5 | 19.8 |
| 6/5/2007 | 21.6 | 20.6 | 21.7 | 21.3 | 19.2 | 19.4 |
| 6/6/2007 | 20.9 | 20.2 | 21.8 | 21.0 | 18.9 | 19.3 |
| 6/7/2007 | 20.9 | 20.2 | 22.1 | 21.1 | 19.3 | 19.5 |
| 6/8/2007 | 20.8 | 20.4 | 22.3 | 21.2 | 19.7 | 19.9 |
| 6/9/2007 | 20.9 | 20.8 | 22.6 | 21.4 | 19.8 | 20.1 |
| 6/10/2007 | 21.3 | 21.1 | 22.8 | 21.8 | 19.9 | 20.4 |
| 6/11/2007 | 21.8 | 21.6 | 22.6 | 22.0 | 20.2 | 20.6 |
| 6/12/2007 | 22.1 | 22.1 | 22.9 | 22.3 | 20.5 | 21.0 |
| 6/13/2007 | 23.3 | 22.7 | 23.8 | 23.3 | 21.3 | 21.6 |
| 6/14/2007 | 24.2 | 23.3 | 24.6 | 24.1 | 21.9 | 22.3 |
| 6/15/2007 | 24.9 | 23.5 | 24.7 | 24.4 | 21.9 | 22.3 |
| 6/16/2007 | 25.1 | 23.7 | 24.7 | 24.5 | 21.8 | 22.3 |
| 6/17/2007 | 25.1 | 23.8 | 24.6 | 24.5 | 21.8 | 22.3 |
| 6/18/2007 | 25.1 | 24.0 | 25.7 | 25.0 | 22.9 | 23.3 |
| 6/19/2007 | 24.6 | 23.7 | 25.8 | 24.7 | 22.3 | 22.5 |
| 6/20/2007 | 23.0 | 23.1 | 25.2 | 23.8 | 21.6 | 22.0 |

Attachment 14-L

# EXHIBIT 13

UNITED STATES DISTRICT COURT

EASTERN DISTRICT OF CALIFORNIA

HON. OLIVER W. WANGER, JUDGE

| | |
|---|---|
| NATURAL RESOURCES DEFENSE COUNCIL, et al., Plaintiffs, | No. 05-CV-1207-OWW |
| vs. | HEARING RE INTERIM REMEDIES DAY 7 |
| DIRK KEMPTHORNE, Secretary, U.S. Department of the Interior, et al. Defendants. | |

Fresno, California — Friday, August 31, 2007

REPORTER'S TRANSCRIPT OF PROCEEDINGS

Volume 7, Pages 1396 through 1699, inclusive

Reported by: KAREN LOPEZ, Official Court Reporter

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INDEX

PLAINTIFFS' REBUTTAL WITNESSES:

CHRISTINA SWANSON 1574
DIRECT EXAMINATION BY MR. WALL 1574

DEFENDANTS' WITNESSES:

JOHN LEAHIGH 1426
DIRECT EXAMINATION BY MS. WORDHAM 1427
CROSS-EXAMINATION BY MS. JAISWAL 1505
CROSS-EXAMINATION BY MR. MAYSONETT 1541
REDIRECT EXAMINATION BY MS. WORDHAM 1543
RONALD MILLIGAN 1547
EXAMINATION BY THE COURT 1547
CROSS-EXAMINATION BY MS. POOLE 1562
CROSS-EXAMINATION BY MR. WILKINSON 1566
CROSS-EXAMINATION BY MR. O'HANLON 1570
RECROSS-EXAMINATION BY MS. POOLE 1572

*****

EXHIBITS

| PLAINTIFFS' | Marked |
|---|---|
| 26 | 1511 |
| 27 | 1533 |
| 28 | 1535 |
| 29 | 1537 |
| DEFENDANTS' | |
| SL I | 1407 |
| SL J | 1408 |
| SL K | 1408 |
| SL L | 1408 |
| SL M | 1408 |
| DWR I | 1438 |
| DWR J | 1438 |
| DWR K | 1440 |
| DWR L | 1441 |
| DWR M | 1442 |
| DWR N | 1456 |
| DWR O | 1485 |
| DWR P | 1485 |
| DWR Q | 1486 |
| DWR Q-1 | 1546 |



EXHIBITS

| PLAINTIFFS' | Received |
|---|---|
| 27 | 1534 |
| 29 | 1537 |
| 19 | 1576 |
| 30 | 1586 |
| DEFENDANTS' | |
| DWR I | 1438 |
| DWR J | 1438 |
| DWR K | 1441 |
| DWR L | 1441 |
| DWR M | 1444 |
| DWR N | 1458 |
| DWR P | 1489 |
| DWR Q | 1490 |

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Friday, August 31, 2007 Fresno California
8:32 a.m.

THE COURT: Good morning, ladies and gentlemen. Please be seated. We're back on the record in NRDC versus Kempthorne. Mr. Lee, are you going -- Ms. Wordham.

MS. WORDHAM: Your Honor, we are prepared to call Mr. Leahigh. However, there is the preliminary matter of DWR's objections to the declaration of Mr. Rosekrans.

THE COURT: All right. What I can tell you is that I have received -- apparently there is a party or parties who want to telephonically observe the proceedings and so they're being connected now.

THE CLERK: Hello. This is the Eastern District of California.

A VOICE: I've got Chris Stevens from the CALFED Bay-Delta program on the line.

MR. STEVENS: Hello this is Chris Stevens from the Bay-Delta Authority in Sacramento.

THE COURT: Okay. Thank you.

Mr. Stevens, can you hear me? This is Judge Wanger.

MR. STEVENS: I can, Your Honor. Thank you.

THE COURT: I understand that you want to observe the proceedings telephonically?

MR. STEVENS: That would be my preference.

THE COURT: All right. Well, with the understanding



that you're not going to participate. Does anybody object?

MS. POOLE: No, Your Honor.

MS. WORDHAM: No, Your Honor.

MR. WILKINSON: No, Your Honor.

THE COURT: All right. Well, then, you will be permitted to observe telephonically with the understanding that you're not going to participate. Do you agree?

MR. STEVENS: I agree, thank you, sir.

THE COURT: All right. Let me indicate that I have objections from the plaintiffs to the admission of the declarations of James Snow, Russ Freeman, Russell D. Harrison, Daniel G. Nelson, Joan Maher, G.F. Duerig. I have the State Water Contractors opposition to those objections. Now, those are the only evidentiary objections I've received.

MS. WORDHAM: Your Honor, the Department of Water Resources reserved its right to make oral objections this morning to the declaration of Spreck Rosekrans.

THE COURT: All right. This would be -- this was identified yesterday as Plaintiffs' Exhibit 24.

I thought there were two declarations of Mr. Rosekrans.

MS. WORDHAM: There are, Your Honor. 24 and 25. We are only objecting to a couple of exhibits in Mr. Rosekrans' July 23rd declaration, which is document No. 420.

THE COURT: All right. You may proceed.

MS. WORDHAM: Your Honor, the Department of Water Resources objects to the Exhibits 4 and 5 of Mr. Rosekrans' July 23, 2007 declaration. The basis for the objection is that as to document 4, there is no citation to it or reference to it in the declaration itself. There's no basis, no foundation for it. Regardless of whether Mr. Rosekrans authored the document, there's no indication in the declaration itself that he relied on it in any part.

As to Exhibit Number 5, again, even though Mr. Rosekrans may have authored the document, there's one single reference to it at, I believe, the last paragraph of his declaration. But it provides no foundation for the document, it provides no support for any of the statements made in the document.

THE COURT: All right. Thank you very much.

MS. POOLE: Your Honor --

THE COURT: Ms. Poole.

MS. POOLE: With regard to Exhibit 4, Mr. Rosekrans' declaration, beginning at around paragraph 25, which is page 7 of 9, discusses alternative water supplies that have been developed in the State of California in the last 15 years. And that discussion relates, obviously, to how they'll respond to reductions in pumping. And that is what Exhibit 4 goes to. Those additional storage facilities.

THE COURT: But without any page and line references,



as I indicated yesterday, I wasn't simply going to read through hundreds of pages of exhibits that have been attached. Because there physically isn't the time to do it. And so he describes what he understands, if you will, additional storage capacity is.

And he doesn't refer to the exhibit nor am I directed to a place within the exhibit where I can find it. He refers, for instance, on page 8 to Article 21, surplus and unscheduled water. And Table A, deliveries. But to the Court's understanding, that would be Table A to Schedule 21.

MS. POOLE: If Your Honor would go to the top of that page, line 1 and 2.

THE COURT: Yes.

MS. POOLE: Looking at page 8 of 9, there's a reference to Diamond Valley Reservoir. That, for example, is one of the facilities identified on Exhibit 4 with the capacity of 800,000 acre feet. And also on paragraph 24 on page 7 of 9, there's a discussion about the contractors making significant investments -- excuse me, Your Honor, I'm at lines 21 through 26.

THE COURT: Yes. Well, I'm going to consider what he says here. The objection is only to the attached exhibit, which is not referred to, incorporated and doesn't appear to be any foundation for.

MS. POOLE: It's not directly referred to, Your



Honor. This discussion is based on information in that exhibit. So we would contend that it is -- should be submitted as a basis for the expert's opinion. But not necessarily for the truth of the matter asserted.

THE COURT: Ms. Wordham.

MS. WORDHAM: Your Honor, notwithstanding counsel's representation, there is nothing in the declaration to indicate that Mr. Rosekrans relied on this document in formulating this opinion.

THE COURT: That does -- go ahead, Ms. Poole.

MS. POOLE: Your Honor, that reference that I just gave to page 7 of 9 at line 22 does refer to Exhibit SR 4 as an explicit reference. That's Exhibit 4 to Spreck Rosekrans' declaration.

THE COURT: All right. I'm going to sustain the objection in part -- is the matter submitted?

MS. POOLE: Yes, Your Honor.

THE COURT: Ms. Wordham?

MS. WORDHAM: Yes, Your Honor.

THE COURT: I'm going to sustain the objection in part. I will consider the attached exhibit because there is a foundation of personal knowledge by the expert, Mr. Rosekrans. There is also a specific reference to SR 4, which is one of the objected to exhibits as providing a list of over 6 million acre feet in recently developed storage. And then there's a



listing about what entities have, in effect, to use the expert's words, invested in those storage facilities.

To that extent, I'm going to consider the declarations for no other purpose. I'm sorry, the exhibit, which is number 4.

Now, as to Exhibit Number 5, Ms. Poole, was there any reference in his declaration to Exhibit 5? And is there any need for Exhibit 5?

MS. POOLE: Yes, Your Honor. If you look at page 8 of 9, paragraph 27, lines 23 through 25. That's an explicit reference to Exhibit 5.

THE COURT: This reads "Finally, much of the water that the CALFED Record of Decision (2000) intended to provide environmental uses has not been made available during recent years. This shortfall, averaging approximately 420,000 to 460,000 acre feet for the 2002-2004 period, is documented in 'Finding the Water,' Environmental Defense 2005 (See Exhibit SR-5)."

There is that one specific reference without giving me a page cite in the exhibit. So that means I have to search the exhibit to find it. What I'll do is this. I'm going to make the same ruling if you'll provide me the page cite within SR-5.

MS. POOLE: I will do that, Your Honor.

THE COURT: All right. Are those the DWR's

1 objections?
2 MS. WORDHAM: That was the extent of DWR's
3 objections, yes, Your Honor.
4 THE COURT: Thank you. Now we'll take up the
5 objections of the plaintiffs to the State Water Contractors
6 offerings and there may be other witnesses from other parties.
7 MR. O'HANLON: Yes, Your Honor. Daniel O'Hanlon.
8 I -- you recall yesterday I did not have with me the redacted
9 form of the declarations that we are offering that the
10 plaintiffs are objecting to. So at this time I'd like to have
11 marked and offered into evidence those declarations.
12 THE COURT: Yes. We had a little difficulty finding
13 them this morning.
14 MR. O'HANLON: Sorry, Your Honor.
15 THE COURT: By the way, let me totally change the
16 subject. A briefcase was left outside the courtroom
17 yesterday. Did the person whose briefcase that is get it?
18 Yes? Good. All right. You may proceed.
19 MR. O'HANLON: Thank you, Your Honor. The first
20 declaration that we're offering is a redacted declaration of
21 James Snow. It was document 410 filed on July 23rd.
22 THE COURT: Which now is Exhibit Number SL --
23 MR. O'HANLON: SL I, Your Honor.
24 (Defendant's Exhibit SL I was marked for
25 identification.)



1 MR. O'HANLON: The second declaration, which will be
2 Exhibit SL J, is a supplemental declaration of Mr. Snow,
3 document No. 462, filed on August 13th.
4 (Defendant's Exhibit SL J was marked for
5 identification.)
6 MR. O'HANLON: The third declaration, which will be
7 SL K, is a redacted version of the declaration of Daniel
8 Nelson, document 460, filed on August 13th.
9 (Defendant's Exhibit SL K was marked for
10 identification.)
11 MR. O'HANLON: The fourth declaration, which will be
12 marked as Exhibit SL L, is document No. 459 filed on August
13 13th, 2007, declaration by Russ Freeman.
14 (Defendant's Exhibit SL L was marked for
15 identification.)
16 MR. O'HANLON: And the final declaration, Your Honor,
17 is Exhibit SL M, is document 463 filed on August 13th, 2007.
18 It's the declaration of William Harrison.
19 (Defendant's Exhibit SL M was marked for
20 identification.)
21 THE COURT: Thank you. Those are objected to
22 declarations along with declarations from State Water
23 Contractors. And so that we're clear, there are objections
24 made on the grounds of relevance, lack of personal knowledge,
25 time consuming, probative, less probative, prejudicial effect



1 under 403 to the James Snow declarations, Russ Freeman,
2 William D. Harrison, Daniel Nelson, Joan Maher, G.F. Duerig.
3 And the opposition to State Water Contractors to
4 these declarations, the Court has -- I received these at about
5 8:10 this morning and I've done my best to read them. So
6 these are your objections, Ms. Poole or Mr. Wall.
7 MS. POOLE: Yes, Your Honor.
8 THE COURT: All right. Do you wish to -- I've read
9 the papers. If you want to provide any argument, you can,
10 otherwise I can rule on the objections.
11 MS. POOLE: Your Honor, I'm happy to submit it on the
12 papers.
13 THE COURT: All right. Thank you.
14 MR. WILKINSON: We are as well, Your Honor.
15 THE COURT: All right.
16 MR. O'HANLON: Your Honor, if I may.
17 THE COURT: Yes, you may.
18 MR. O'HANLON: One additional point in addition to
19 the points made by the State Water Contractors, which we join
20 in. There's an additional reason why these declarations are
21 relevant to the Court's consideration and that is under the
22 Endangered Species Act, a major change to project operations
23 can be required only if necessary to avoid jeopardy. These
24 declarations help establish which of these actions will
25 require major action meter changes to project operations and



1 therefore are relevant under the substantive provisions of the
2 ESA as well.
3 THE COURT: Thank you very much. Ms. Poole.
4 MS. POOLE: May I briefly respond to that, Your
5 Honor?
6 THE COURT: Yes.
7 MS. POOLE: There's no distinction within the
8 Endangered Species Act injunctive relief guidelines for major
9 changes versus minor changes. That's irrelevant as are all
10 cost discussions. The issue is whether actions can go forward
11 that will not jeopardize the species or cause adverse
12 modification of habitat. That's the sole issue Your Honor
13 should be focused on here.
14 THE COURT: All right. Thank you very much. Is the
15 matter submitted?
16 MR. WILKINSON: Yes, Your Honor.
17 MR. O'HANLON: Yes, Your Honor.
18 THE COURT: The Court notes that the plaintiffs have,
19 in their remedies proposal and their briefs in support of
20 these proceedings, offered, and they haven't provided specific
21 language, but they have indicated that they recognize that
22 there should be a public health and safety exception to any
23 interim order that the court were to enter.
24 And they distinguish between economic loss, costs
25 that would be not only monetary but resource or other material

or tangible costs as allegedly irrelevant from actions that would directly cause a risk to human health, safety, the human environment, which they have from the outset indicated that such an exception should be part of any order that is issued.

The Court has based rulings on that general demarcation which applies under the Endangered Species Act. We have a Biological Opinion that was vacated under the authority of the Administrative Procedures Act.

And to the extent that we are going to be addressing the form, the substance, the effect, the scope, the operation and the intent of any remand, with or without vacatur, any other specific orders that the Court enters that would affect the agency, any operation of its ordinary course of business and the conduct of its statutorily mandated and authorized duties, the Court believes there is a two-fold, if you will, legal and equitable basis on which this relief is sought.

Because the Biological Opinion and its contents, including the take limits and remedial action measures, the DSRAM, D-S-R-A-M, all of that was done under the provisions of administrative law.

The Court believes that administrative law continues to apply in any relief that will be granted as well as, as of yesterday, there is now amended species or there are, I guess there's more than one, amended species claims before the Court which the Court understands, based on the form of remedy that



is sought, is in effect a claim for injunctive relief for violations that are alleged of the Endangered Species Act.

So this is, if you will, a dual proceeding. It proceeds both under the Administrative Procedures Act and that jurisprudence and the injunction jurisprudence that attaches to APA cases, judicial review of administrative actions under Title 5, Section 702, et seq.

And it is also an Endangered Species Act case now, at least as of yesterday, as to the action agency the Bureau of Reclamation. And so the law that applies, that has been correctly cited by the plaintiffs, continues to apply.

It is my view that because the Court has the responsibility to understand and to endeavor to protect all the interests that are represented in the litigation and that are before the Court, that for limited purposes, the effect on human health, safety and the environment would include water costs because those affect the operations of the projects.

The operations of both the state and the federal project have the potential not only to harm this species but other species. There is direct reference made to the winter-run Chinook salmon and other salmonid species that are potentially affected by actions that are proposed to be implemented under an order that the plaintiffs seek.

Day-to-day operations of the projects, because they directly impact water service districts, emergency service



districts, municipal water supplies and industrial power and related energy sources have direct effect on human health and the environment.

And so the Court is satisfied that that evidence is not irrelevant and that, in terms of being able to evaluate the overall effect of any injunctive relief, that to not consider it would be an abuse of discretion because the Court would, in effect, be foreclosing the exercise of its legal and equitable judgment and ultimately discretion to determine what remedies, if any, are appropriate. There's no way to fully analyze and determine the ultimate effect of those remedies without considering this evidence.

As to -- when we get to -- so that covers, I believe, the State Water Contractors, who are municipal and industrial users. It covers, to the extent that water districts supply water for not just irrigation purposes, but for related purposes because we know that there are additional purposes besides only irrigation purposes.

But to the extent that water shortages, if under certain scenarios there would be zero water available, for instance, for irrigation districts in the next water year if it continues to be dry, we would be looking at alternate water sources by the irrigation district members who would be, as the Court knows, could take judicial notice of it, relying on groundwater, water exchanges, other types of sources.



And given the potential effects of groundwater pumping with regard to overdrafting water tables, causing subsidence, creating air pollution potential, those kinds of risks are also both environmental and affect human health and safety. And so they really cannot be ignored.

In terms of ultimately, if the economic losses are converted into what would be, if you will, the human result, where employment is ended, jobs are lost, communities that depend on people who are employed in agriculture are unemployed and, in effect, although we're not, under the Endangered Species Act, concerned about the dollar effect of that on parties.

When what we are talking about is the health of a community, of the ability of its citizens and participants to have livelihoods and to be able to maintain themselves, that is an indirect -- it is somewhat remote, but it is an indirect potential effect.

And the Court -- because we have this, if you will, dual jurisdiction under the APA and the ESA, should not be entirely ignored. I don't intend to spend any time on it except to have what direct effects the parties who are relying on these matters in a declaration form. All I want in their arguments is for those to be summarized, cataloged and then I'll let the plaintiffs specifically respond to those. But I'm not considering it beyond that and for any other purpose.

So the objections are sustained in part consistent with my prior rulings, but adding the additional grounds that I have just added.

MS. POOLE: Thank you, Your Honor.

THE COURT: All right. Are we ready to proceed with --

MR. ORR: Your Honor, one other --

THE COURT: Yes, Mr. Orr.

MR. ORR: Good morning, Your Honor, Trent Orr for the plaintiffs.

THE COURT: Good morning.

MR. ORR: One brief housekeeping matter which Your Honor indicated he didn't want to fall between the cracks, which is this question of --

THE COURT: Oh, the time to respond. Yes.

MR. ORR: Yes. We've conferred and, you know, we would prefer something on the order of 30 days.

THE COURT: 30 days. That's what the Court was thinking.

MR. ORR: Yeah.

THE COURT: And we're not meaning to inconvenience you personally, Mr. Lee, but Ms. Wordham is in the case, she's been in it all the way, and so my inclination is to give all the responding parties 30 days to respond and we'll run that from the date that the second supplemental complaint was



filed, which was the 30th of August. Can you live with that?

MR. LEE: Could I just confer with my co-counsel just for a minute?

THE COURT: Yes, you may. What about other parties while they're conferring?

MR. O'HANLON: Yes, Your Honor.

MR. MAYSONETT: Your Honor, that's acceptable to the federal defendants.

MR. BUCKLEY: No problem with that, Your Honor, for the Farm Bureau.

MS. McDONALD: That is fine, Your Honor. Thank you.

THE COURT: Mr. Wilkinson?

MR. WILKINSON: We'll struggle through it, Your Honor.

THE COURT: We're all struggling. Mr. Lee? Ms. Wordham?

MS. WORDHAM: Your Honor, as Mr. Lee represented yesterday, he departs on vacation for about a three-week period beginning the end of this week. Next week. Sorry. My apologies. What I would suggest is that -- so an additional -- 45 days would be the minimum required for Mr. Lee to respond.

I would offer to respond, but I have a wealth of cases that have been neglected in the last couple of weeks as I'm sure other counsel have. And Mr. Lee has been the primary



attorney on this matter on behalf of the Department of Water Resources.

What I would suggest is, if the plaintiffs would agree to this, the Department of Water Resources could agree to comply with the Court's ordered remedy today voluntarily and then the issue of whether this Court ultimately has jurisdiction over the department for the plaintiffs' failure to serve a 60-day notice on the department for its EPA actions could be addressed subsequently following DWR submission of a 12(b) rule motion.

THE COURT: Mr. Orr?

MR. ORR: I would provided they're willing to submit themselves to the Court's jurisdiction in the interim, that would be fine.

THE COURT: That is what was just stated. And I believe that I can trust Ms. Wordham to be consistent with her representation.

All right. Then every party except the DWR shall respond within 30 days following -- let's have a date, please, Ms. Timken.

THE CLERK: You want it at 30 days from the August 30th; correct? October 1st.

THE COURT: It will be October 1st. And for DWR only, it's October 15th. Are those week days?

THE CLERK: Yes.



MR. ORR: Thank you, Your Honor.

THE COURT: You're welcome. With the condition that the DWR's response is on the express undertaking that the DWR consents to the Court's jurisdiction for the imposition of any remedy that may be pronounced in these proceedings. Ms. Poole.

MS. POOLE: Your Honor, one final housekeeping matter. I have that page reference for the Rosekrans declaration document 420, which has been marked Plaintiffs' Exhibit 25. On page 8 of 9 of that exhibit at line 25, the page reference to Exhibit 5 would be roman four.

THE COURT: Thank you very much. And I will look at that declaration now to make sure that I can find it. Is that in Exhibit 24 or 25? It's in 25.

MS. POOLE: I believe it's Plaintiffs' Exhibit 24.

THE COURT: I think it's 24 too.

MS. POOLE: Oh, you're correct, Your Honor.

THE COURT: It is 24. That was my concern because those exhibits are not present on this.

All right. And I'm just going to look at Exhibit 5. You said page roman numeral four?

MS. POOLE: Correct.

THE COURT: Is that the executive summary, page six of 32? Document 420-3.

MS. POOLE: Yes, Your Honor.

THE COURT: All right. I have it. Thank you very much.

All right. Are we ready to proceed with evidence?

MR. LEE: Yes, Your Honor.

THE COURT: You may proceed, Mr. Lee.

MR. LEE: We would like to divide it up in the following fashion. I would like to make a brief opening statement on behalf of the State of California and Ms. Wordham, then, will conduct the direct examination of our one witness.

THE COURT: All right. You may proceed with your opening statement.

MR. LEE: Your Honor, there have been extensive briefing in this case and we do not intend to repeat the vast quantity of material that has been presented. We see that there are basically two components to the evidence that are coming in. The first component we have heard a lot of to date, which is the biological evidence regarding the delta smelt and its condition.

The second component is what we are just commencing today, which is the operational consequences of the respective remedy proposals on project delivery.

In order to meet our requirement of having one live witness and to minimize duplicate testimony and also to encourage the best use of this Court's time, DWR has not and



will not be introducing any testimony regarding biological issues relating to the delta smelt.

We will rely instead on the biological testimony of Ms. Cay Goude as presented by the United States and the testimony of Dr. Charles Hanson as presented by the State Water Contractors and any declarations that are appropriately considered by this court.

DWR will limit its testimony on direct to the introduction of evidence through the Department of Water Resources engineer John Leahigh regarding the operational costs of the respective remedies in terms of water deliveries and exports.

We will have four general points. The first point will be Mr. Leahigh will discuss the water costs of the respective proposals. He will discuss the water costs, first of all, in plaintiffs' revised proposal.

Just by way of peek and summary, we have determined that the low end of that water cost in an average year would be 2.5 million acre feet and the high end of that cost, water cost in an average year might be as much as 3.5 million acre feet.

In a dry year, the plaintiffs' revised proposal would have a low end water supply cost of 1.1 million acre feet and a high end water cost of a 1.6 million acre feet.

These spreads in costs are due to the fact, as this



court is aware, that most of the remedy proposals have ranges of protections. And therefore, the ranges of the costs are reflective of the ranges of the protections.

THE COURT: I know we'll get there, but why is an average year a higher water cost than a dry year?

MR. LEE: Well, Your Honor, this will be explained in some detail by Mr. Leahigh. My understanding is that in a dry year, there is generally, notwithstanding the impositions of the remedies, significant reductions in deliveries already built into the system. And so it's a -- it's a narrower and smaller base.

THE COURT: All right. So those are the contractual terms that excuse delivery of water in shortage periods?

MR. LEE: If there isn't water in the system, we can't deliver it, Your Honor.

THE COURT: All right. Thank you.

MR. LEE: The next remedy proposal was the US Fish & Wildlife Service matrix that was presented by Ms. Goude. This has a lesser impact on water supply and the average year low end range of the water cost is roughly 820,000 acre feet. The high end average year water cost, however, could be as much as 2.1 million acre feet. In a dry year, the low end cost would be 183,000 acre feet with a high end cost of possibly 814,000 acre feet.

Now, the Department of Water Resources has embraced,



for the most part, the US Fish & Wildlife Service matrix, but we have two minor modifications which we will address in direct examination. Which does alter the water costs.

And in those situations, on an average year, the modified US Fish & Wildlife Service matrix, as proposed by the Department of Water Resources would have a low end cost in an average year of 476,000 acre feet and a high end cost of 1.4 million acre feet. In a dry year, the low end cost would be 84,000 acre feet and a high end cost could be 415,000 acre feet.

Now, there is one last proposal that we've had discussed here over the last seven days and that's the State Water Contractors proposal. We are -- will not be able to provide this Court, unfortunately, with a full water cost of this proposal.

We are going to be able to provide this Court with an estimate of the cost of tier one. Their Q west or westerly flow, which I believe will be 316,000 acre feet.

However, due to the contingent nature of the remaining State Water Contractor proposals tiers, and there's a tier two and a tier three and a tier four, the Department of Water Resources has been unable, in the short time frame in this trial, to be able to develop a full set of water cost estimates for the State Water Contractor proposal.

So that's the first issue.

THE COURT: Yes. And when we're talking about all of these quantitative measures of water, this is for the State Water Project only.

MR. LEE: No, Your Honor --

THE COURT: This is not -- is this combined or only State Water Project?

MR. LEE: We are going to provide you with a total package on this. This will be both for the State Water Project and the Central Valley Project.

THE COURT: Thank you.

MR. LEE: The second area which we will get into is some discussion of the issues raised in the plaintiffs' declarations by Spreck Rosekrans regarding the plaintiffs' view of the operational consequences of the remedy measures. In a nutshell, we will -- we will contend that reliance solely on past historic conditions is an unwise practice when projecting water delivery costs for new water year.

Such short term projections must rely on real world hydrologic data regarding runoff, storage and demand in order to secure an honest assessment of water supply costs.

If there's a simple principle here, Your Honor, it's a principle that all engineers in the water business seem to operate under. Which is you hope for the best, but you must plan for the worst.

Third issue, which we intend to address, is the fall



actions as proposed by the plaintiffs for salinity control in the western Delta --

THE COURT: Why don't we call that measure ten.

MR. LEE: Yes, that's measure ten on the project's operations with an emphasis on the adverse impacts, the potential adverse impacts on other listed species and on potential health and safety issues relating to project operations and project deliveries.

Lastly, Mr. Leahigh will touch upon the dispute the plaintiffs and the Department of Water Resources have had in our pleadings regarding the use of appropriate averaging period for the flow measures.

This is this question of whether we should be using a 14-day running average or a five-day running average. Mr. Leahigh will explain that and indicate why we believe a 14 or 7-day running average is appropriate given the hydrology of the system.

There will be a few miscellaneous operational issues, which we will address. But these are the key points.

THE COURT: All right.

MR. LEE: In conclusion, we anticipate that the plaintiffs may object to some of Mr. Leahigh's testimony. In response, we would note that the DWR stresses that we submit that this Court has a responsibility to narrowly tailor the remedy order --



THE COURT: I've already ruled on the objections. I'm going to offer the plaintiffs a continuing objection so we don't have to interrupt the testimony unless they want to do it otherwise.

MR. LEE: All right. We would just note that DWR received surprising support for this concept of narrowly tailored approach in Wednesday's testimony by Dr. Swanson. Dr. Swanson noted that the plaintiffs had, at the very 11th hour in this case, revised their fish actions four, five and seven to remove the inflexible target flow of 1500 cfs for Old and Middle River and to replace those flows with a more flexible range of flows from a lower end range to a higher end range.

Now, surprisingly Dr. Swanson did not justify this new range of flows based upon improved biological protection for the smelt, but instead said on Wednesday the range would make it easier for the projects to operate.

In setting this Court's remedy proposal, DWR simply asks this Court to adopt the same approach. If the evidence shows that more than one remedy proposal is biologically defensible, then this Court should also choose the remedy that is easier for the project to operate.

And with that, Your Honor, Ms. Wordham will be prepared to put on our case.

THE COURT: Thank you, very much, Mr. Lee. Ms.



Wordham, you may proceed.

MS. WORDHAM: Thank you, Your Honor. The Department of Water Resources calls Mr. John Leahigh.

MS. JAISWAL: Your Honor, Anjali Jaiswal on behalf of plaintiffs. I just wanted to inform the Court that plaintiffs will be accepting the continuing objections to Mr. Leahigh's testimony.

THE COURT: All right. Thank you very much. And I have sustained the objection in part consistent with the ruling I just announced on the evidence. Your objections that were submitted in writing to other, I'm going to call it omnibus cost, which I think is inseparable from human health and safety concerns. And so that's the basis for my ruling.

Any objection to the continuing objection?

MS. WORDHAM: No objection, Your Honor.

MR. WILKINSON: No, Your Honor.

THE COURT: All right. Please swear the witness.

JOHN LEAHIGH,

called as a witness on behalf of the Defendants, having been first duly sworn, testified as follows:

THE CLERK: Please state your full name for the record and spell your last name.

THE WITNESS: John Leahigh, last name is spelled L-E-A-H-I-G-H.

THE COURT: You may proceed, Ms. Wordham.

DIRECT EXAMINATION

BY MS. WORDHAM:

Q. Good morning, Mr. Leahigh. Would you please provide the Court with your educational background.

A. Yes. I have a bachelors degree in civil engineering from the University of New Mexico. Also have a masters degree in civil engineering with emphasis in water resource management from California State University at Sacramento.

Q. Where are you currently employed?

A. Currently employed with Department of Water Resources. State Water Project Operations Planning Branch Chief.

Q. Your title is chief?

A. Yes.

Q. Of the plan --

A. Of the State Water Project Operations Planning Branch.

Q. How long have you been with the Department of Water Resources?

A. Been with the Department of Water Resources since 1992.

Q. And how long have you held your current position?

A. My current position for two years, although the current responsibilities I've had since 1999.

Q. Would you please describe your responsibilities?

A. Yes. I lead a team of engineers that are responsible for the water management decisions for the State Water Project. This would include forecasting the operations for the State



Water Project and its -- and the Central Valley Project.

We're responsible for recommending the water delivery allocations for the State Water Project to the director of the Department of Water Resources. We are responsible for short term and scheduling of releases from Lake Oroville to the Feather River. And the export of water in the south Delta at the SWP export facilities in compliance with all contractual and regulatory obligations.

Q. So your responsibilities include estimating water deliveries for the coming water year; is that correct?

A. That's correct.

Q. When estimating water deliveries, what factors do you consider?

A. Factors we consider is essentially we need estimates for the supply and the demand in the upcoming year. And we need to feed those into a model which represents all of the constraints that exist in the system.

Q. So you have supply, demand and system constraints; is that correct?

A. That's correct.

Q. Under demand, what components determine demand on an annual basis?

A. The demand estimates we get directly from our water users. And this is in terms of volume and also a demand pattern. So the timing of that demand is very important.



Q. What component do you consider when -- for determining supply on an annual basis?

A. For supply, it's really broken down to two aspects. Two components. One is the stored water available to the project, carried over from the previous year. So this would be storage in Lake Oroville, the state share of San Luis Reservoir. This can be reliably projected from one year to the next, going into the next year.

The other component would be the unstored flow or natural flows that would enter the system as a result of precipitation in the next year. And this is highly variable. So the estimates must be taken -- must be in terms of probabilities, in terms of what the observed hydrology has been in past years.

Q. Is there a way that you characterize your estimate for forecasted runoff?

A. Yes. As far as the estimate, as far as the official water supply allocations that we make to our contractors, that is based on what is called a 90 percent exceedance probability.

Essentially that's where taking a look at the past record hydrology, 90 percent of the years would have exceeded that assumption of hydrology. So it is a very conservative assumption for hydrology going into the next year. A very dry year type.

Q. So 90 percent exceedance would be considered a dry year;



is that correct?

A. That's correct.

Q. Do you ever estimate future runoffs based on any other exceedance level?

A. Yes. Typically we also look at a 50 percent exceedance level, where half the historical record is drier and half wetter. So this represents an average condition for hydrology for the coming year. And that's kind of supplemental information for planning purposes.

Q. But for purposes of your official allocation, you use the 90 percent exceedance; is that correct?

A. That's correct.

Q. Do you ever use an above normal or a wet year for projecting water deliveries?

A. Occasionally we will take a look at a wetter scenario, say, a 25 percent exceedance where only 25 percent of the historical record is wetter. There's less value to us in looking at those wetter cases. Typically, at the 50 percent hydrology we're able to meet most of the delivery requests for contractors. So the assumption is anything wetter than that, we're able to meet those commitments.

Q. You would never use an above average or a wet year for projecting official delivery allocations; is that correct?

A. Not for the official delivery allocation, no.

Q. In addition to demand and supply, you also mentioned

system constraints; correct?
A. That's correct.
Q. What are the system constraints that are factored in to your delivery estimates?
A. Well, the system constraints would include all physical and regulatory constraints on both the storage and conveyance in the system. So, for example, as far as Lake Oroville is concerned, physically we could store 3.5 million acre feet in storage. However, in the wintertime, we're restricted to 80 percent of that storage due to regulatory requirements for flood control purposes.
We have other constraints downstream, for example, minimum flow requirements on the Feather River for fishery --
THE COURT: Let me interrupt, if I could, for a second.
THE WITNESS: Yes.
THE COURT: Just so that we have it. Is this every winter that the flood control limit is 80 percent of capacity?
THE WITNESS: That's correct. And that's a requirement from the United States Army Corps of Engineers.
THE COURT: And so approximately 280,000 acre feet are not in the reservoir year in and year out for flood control purposes. It's release -- the water is released out of the reservoir?
THE WITNESS: If we encroach into that required top



20 percent that's reserved for flood control, we must release that water downstream and maintain vacant space in the event that there's a large storm event to capture the runoff.
THE COURT: And that's year round. So that is -- that's an operative level, that's the maximum capacity for Lake Oroville.
THE WITNESS: That makes a regulatory limit on the amount of storage that we can hold in the wintertime.
THE COURT: Winter.
THE WITNESS: Winter, right.
THE COURT: All right. Thank you. You may proceed.
BY MS. WORDHAM:
Q. You've just finished describing the storage capacity. Are there any other elements that -- any other system constraints that are factored in to your delivery estimates?
A. Yes. I think I talked about the minimum instream requirements to the Feather River. There are also a number of constraints related to managing the Delta. And that includes flow requirements. Delta outflow requirements. Salinity management. Number of salinity requirements. And there are also export limitations for fishery benefits as well.
Q. Are these objectives that you just described, are they the objectives that are outlined in State Water Resources Control Board Decision 1641?
A. Yes. All those Delta requirements are outlined in that



document.
Q. Are you responsible for estimating --
THE COURT: Let me ask one question before you continue.
MS. WORDHAM: Certainly, Your Honor.
THE COURT: Does the operational regime that you manage take in any consideration of the Central Valley Project Improvement Act?
MS. WORDHAM: You anticipated my question, Your Honor.
THE COURT: Do any of those requirements apply to the state operations?
THE WITNESS: No. Those requirements do not apply to the State Water Project. That is a Central Valley Project program.
THE COURT: Thank you.
BY MS. WORDHAM:
Q. Are you responsible for estimating Central Valley Project water deliveries?
A. It's important to -- yes, we have that capability in our model. We have all of their constraints built within our model as well. So we have the capability of estimating their delivery capabilities. And we get input from the CVP on their operations.
Q. But you're not responsible for estimating their



deliveries, you just have the capability?
A. That's correct.
MS. WORDHAM: Your Honor --
THE COURT: I'm going to ask a question. Do you operate the SWP under a cooperative regime, if you will, the OCAP, for coordinated operations or you operate independently?
THE WITNESS: No, we -- the two operations are very much intertwined. As far as the Bay-Delta requirements that we just described, both projects are responsible for meeting those. And there's a sharing formula for that that is part of our coordinated operations agreement or COA, which is an important component into determining the delivery capabilities of both projects.
THE COURT: Thank you. You may continue.
MS. WORDHAM: At this time, Your Honor, I would like to move that Mr. Leahigh be accepted as an expert on the State Water Project and, where it coordinates with the Central Valley Project, on the Central Valley Project as well, of the regulatory and hydrological conditions of the project operations as they relate to water exports and delivery.
THE COURT: Is there any objection?
MS. JAISWAL: No objections, Your Honor.
THE COURT: All right. The Court accepts the tender of Mr. Leahigh as an expert by background, experience, education and training on the subjects of the coordinated

operations of the State Water Project and the Central Valley Project, including compliance with all regulatory requirements, hydrologic management and water supply delivery concerns. You may continue.

BY MS. WORDHAM:

Q. Mr. Leahigh, you've just outlined the factors that you look at in estimating water deliveries. What do you do with these factors?

A. Well, the estimates of supply and demand are input into a simulation model that we have, which has all of the constraints, both physical and regulatory built in to it. We use this as a tool to estimate what the maximum deliveries that would be -- that we'd be capable of delivering, given all the constraints in the system.

THE COURT: Is this annual?

THE WITNESS: Yes. This is annual. And we actually update these estimates as we step through the year.

THE COURT: And when does the water year start for the state?

THE WITNESS: Well, the contract -- the delivery year is the calendar year.

THE COURT: Is there any different time period for operations?

THE WITNESS: Well, the water year is from October through September.



THE COURT: October 1st through September 30th. So it's the same as for the CVP?

THE WITNESS: The water year is the same. The CVP's contractual delivery year is slightly different, it is March through February.

THE COURT: Thank you.

BY MS. WORDHAM:

Q. The model you refer to, does that model have a name?

A. Yes, it's the Delta Coordinated Operations model or DCO for short.

Q. And this is the same model that you have used for estimating water cost associated with implementing the US Fish & Wildlife remedy proposal that was submitted in this matter?

A. That's correct.

Q. Is it the same model that you used for estimating the water cost associated with all of the remedy proposals submitted in this matter?

A. Yes.

THE COURT: And how long has that model been in operation?

THE WITNESS: We've used that model for estimating deliveries since about 1995, '96.

THE COURT: Thank you. You may continue.

BY MS. WORDHAM:

Q. Mr. Leahigh, you've just testified that the water year is



from October through September; is that correct?

A. That's correct.

Q. So we are currently in the 2007 water year; would that be correct?

A. That is correct.

Q. How would you characterize the current water year?

A. Officially, the water year type for the Sacramento basin is dry. For the San Joaquin basin, it's actually critically dry this year. And as you move south, it's -- it's very dry. In fact, Los Angeles is -- this is the driest year on record for Los Angeles in 130 years of record.

Q. Mr. Leahigh, you have projected water costs associated with the various remedy proposals submitted in this proceeding; is that correct?

A. I'm sorry? Would you repeat the question?

Q. You've projected water costs associated with each of the remedy proposals submitted in this proceeding?

A. Yes.

MS. WORDHAM: Your Honor, at this time, I'd like to mark the declarations of Mr. John Leahigh submitted in this matter. These will be DWR next in order.

THE COURT: What is the next exhibit?

MS. WORDHAM: I, I believe.

THE CLERK: I.

THE COURT: It will be DWR I for identification.



(Defendant's Exhibit DWR I was marked for identification.)

MS. WORDHAM: And that will be the declaration of John Leahigh filed on July 9th, 2007, document No. 398.

THE COURT: Any objection to its admission?

MS. JAISWAL: No, Your Honor.

THE COURT: Subject to my earlier ruling. Thank you.

All right. Subject to my earlier ruling on the evidentiary objections, DWR I is received in evidence.

(Defendant's Exhibit DWR I was received.)

MS. WORDHAM: And then the supplemental declaration of John Leahigh filed on August 3rd, 2007, document No. 428.

THE COURT: This will be DWR J.

(Defendant's Exhibit DWR J was marked for identification.)

THE COURT: And I will receive DWR J subject to the plaintiffs' objections and my ruling on those objections.

(Defendant's Exhibit DWR J was received.)

MS. WORDHAM: If I may approach the witness, Your Honor?

THE COURT: You may.

BY MS. WORDHAM:

Q. Mr. Leahigh, do you recognize the two documents I've just handed you?

A. Yes.

Q. And could you please describe them?
A. Well, the first one is my original declaration dated July 9th. And the second is my supplemental declaration dated August 3rd.
Q. And if you will look at the exhibits to your August 3rd declaration, there are numerous exhibits; are there not?
A. Yes.
Q. Do you recognize all of these exhibits?
A. Yes, I do.
Q. There are several tables in this -- in your exhibits. Do you know who prepared these tables?
A. Yes, my staff under my direction.
Q. There's also a map that is your Exhibit E. Do you know how this map was prepared?
A. Yes. By my staff under my direction.
Q. And lastly, Exhibits A and B, would you please describe these exhibits.
A. Exhibits A and B define the water year type. Exhibit A is definition for water year type for the Sacramento Valley basin and Exhibit B is definition for water year type for the San Joaquin River basin.
Q. Where did these exhibits come from?
A. They come from -- originally from water quality control plan, which was incorporated into decision 1641.
MS. WORDHAM: At this time, Your Honor, I'd like to



move Exhibits -- DWR Exhibits I and J into evidence.
THE COURT: I've already received them in evidence subject to the plaintiffs' objections. They're in.
MS. WORDHAM: Thank you, Your Honor.
Q. Mr. Leahigh, if you would turn to Exhibits C and F of your August 3 declaration, which is DWR Exhibit J.
A. Okay.
Q. I think you have just testified that you prepared -- or your staff prepared these tables under your direction; is that correct?
A. That's correct.
Q. At this time, just for ease of reference, Your Honor, I would like to mark Exhibit C to Mr. Leahigh's August 3 declaration as DWR next in order K.
(Defendant's Exhibit DWR K was marked for identification.)
THE COURT: All right. DWR K is what? A table?
MS. WORDHAM: And Exhibit F --
THE COURT: Let me describe K. It is a water cost analysis. And it appears to be demonstrative or illustrative. Any objection to the admission of DWR K?
MS. JAISWAL: No, Your Honor. Just based on our earlier objections and your ruling.
THE COURT: Thank you. Subject to my rulings on plaintiffs' earlier objections, DWR K is received in evidence.



(Defendant's Exhibit DWR K was received.)
MS. WORDHAM: And similarly, I would like to move -- I would like to mark as DWR's next in order, L, Exhibit F to Mr. Leahigh's August declaration.
(Defendant's Exhibit DWR L was marked for identification.)
THE COURT: Any objection to L?
MS. JAISWAL: The continuing --
THE COURT: The same? All right. We will receive DWR L subject to my ruling on plaintiffs' objections. It's in evidence.
(Defendant's Exhibit DWR L was received.)
MS. WORDHAM: And just to get all of these tables in at once.
THE COURT: It is also a water cost analysis, Exhibit L.
MS. WORDHAM: Yes. For clarification, DWR Exhibit K is a comparison of the plaintiffs' remedy proposal as submitted on July 9th, 2007 with the US Fish & Wildlife Service Action Matrix also submitted to this Court on July 9, 2007.
Exhibit C -- I mean Exhibit F, I apologize, which is DWR Exhibit L is a comparison of the US Fish & Wildlife Action Matrix with the US Fish & Wildlife Action Matrix as modified by the Department of Water Resources.



Next I would like to mark as Exhibit DWR M a table which may need some foundation.
(Defendant's Exhibit DWR M was marked for identification.)
THE COURT: So you're going to lay a foundation for this?
MS. WORDHAM: Yes, Your Honor.
THE COURT: You may proceed.
MS. JAISWAL: Your Honor, we haven't received a copy. Thank you.
MS. WORDHAM: For identification, what has just been marked as DWR Exhibit M is another water cost analysis. And this is a comparison of the water cost associated with the plaintiffs' remedy proposal submitted, this says, on July 23rd. I believe that -- and I think that's correct. I think I had previously represented that the plaintiffs' proposal had been submitted on July 9th, so I stand corrected. So this --
THE COURT: You intended to say the 23rd.
MS. WORDHAM: I did, Your Honor.
THE COURT: All right. So that would be for DWR I.
MS. WORDHAM: That is correct, Your Honor. K. K.
THE COURT: Thank you.
MS. WORDHAM: So this compares the plaintiffs' proposal as submitted on July 23rd with their proposal as submitted on August 13th. If I may approach.

THE COURT: You may.
BY MS. WORDHAM:
Q. Mr. Leahigh, I've just handed you what has been marked as DWR Exhibits K, L and M. Do you recognize these documents?
A. Yes.
Q. Would you please briefly describe them?
A. Yes. The Exhibit that's marked DWR K is the water cost analysis which compares the plaintiffs' original remedy proposal with US Fish & Wildlife Service Action Matrix.
Exhibit L, DWR L is the water cost analysis comparing US Fish & Wildlife Service Action Matrix to that same matrix as modified by DWR. And both of those two exhibits were exhibits to my supplementary declaration.
The document, DWR M, is a water cost analysis comparing the plaintiffs' proposal, original proposal as of July 23rd with the revised plaintiffs' proposal dated August 13th.
Q. Mr. Leahigh, you testified that Exhibit C and F were prepared by your staff under your direction; is that correct?
A. That's correct.
MS. WORDHAM: At this time, Your Honor, I'd like to move Exhibits -- DWR Exhibits K and L into evidence.
THE COURT: I believe we've received K into evidence. We've also received L into evidence. And so all that is left is M.



MS. WORDHAM: Thank you, Your Honor.
Q. Mr. Leahigh, turning to DWR Exhibit M, did you prepare this table?
A. It was prepared by my staff under my direction.
Q. Using the same criteria as Exhibit C and F, which would be DWR's K & L?
A. Yes. Using the same model. Same methodology.
MS. WORDHAM: At this time, Your Honor, I would like to move DWR Exhibit M into evidence.
THE COURT: And I will admit it subject to the plaintiffs' objections and my ruling on those objections.
MS. WORDHAM: Thank you, Your Honor.
THE COURT: M is received in evidence.
(Defendant's Exhibit DWR M was received.)
BY MS. WORDHAM:
Q. Mr. Leahigh, would you please just generally describe what is contained in these exhibits? In these tables.
A. Yes. I mean, generally it -- it is a comparison of the various remedy proposals. And it is broken down by action. And what we attempted to do here was -- a lot of the actions are similar between remedy proposals. So we attempted to show -- to line up the appropriate action numbers for one proposal and the corresponding action that takes place in the alternative proposal.
Q. And you have broken it down by the different actions that



each proposal includes; is that correct?
A. Yes. For example, US Fish & Wildlife Service matrix is broken down into each of its five actions and the plaintiffs' proposals are broken down into actions one through ten.
Q. Thank you. Looking at the --
THE COURT: Let me ask one question. I withdraw my question. I see that you have addressed number ten here. You may continue.
MS. WORDHAM: Thank you.
Q. Looking at DWR Exhibit M, looking at the plaintiffs' revised proposal, would you please describe the costs that are associated with plaintiffs' action numbers one through three?
A. Well, there's no cost associated with those three. Those were -- those actions had to do with changes in monitoring.
Q. So those do not affect exports?
A. Those do not affect exports.
Q. Looking at plaintiffs' action in its revised proposal, action number four. Would you please describe the water costs associated with plaintiffs' action four?
A. Well, in all these proposals, we have a range given for potential impacts. And that was looking at each proposal under the average year scenario that was described earlier and the dry year scenario described earlier.
So for this particular action four, there are two components to their action four. One is a shorter duration,



ten-day export reduction. The other is a -- and this -- well, it's an objective for Old and Middle River flow.
And the way to meet that objective is with an export reduction is the assumption here. The cost associated with that particular action averaged, in an average year, estimated cost is a total of 800,000 acre feet. And in a dry year, 400,000 acre feet.
Q. Let's walk you through this a little more, in a little more detail, if you don't mind. And let me preface this, lay a little bit of a foundation.
You are familiar with the plaintiffs' revised proposal that was submitted on August 13th, 2007; is that correct?
A. Yes.
Q. And you are familiar with the flow recommendations they have included in their proposal; is that correct?
A. Yes.
Q. So for the first part of the plaintiffs' action four, the December 25 through January 3 period, as I read your flow objectives column, the plaintiffs' proposal would require that Old and Middle Rivers -- and I'm -- am I correct in assuming that "OMR" stands for Old and Middle Rivers?
A. That's correct.
Q. The objective would be to maintain flows in Old and Middle Rivers at zero cubic feet per second; is that correct?

A. Correct. Essentially achieving non-negative flows in Old and Middle River.

THE COURT: For ten days?

THE WITNESS: Yes. For ten days. The assumption here, that action could be triggered at any time during that period in the pre-spawning period. The assumption that we make here was that it was triggered at the -- the first day that would be possible to trigger it, which would be December 25th. And so it's triggered for ten days following December 25th.

THE COURT: What was the reason for choosing December 25th as opposed to December 1st?

THE WITNESS: I believe the plaintiffs' proposal identifies December 25th as the first possible date to trigger this action.

THE COURT: And that's the reason it was selected?

THE WITNESS: That was the reason it was selected.

THE COURT: Thank you. And this action lasts until when?

THE WITNESS: It lasts until -- the duration is ten days, so the ending date was January 3rd. And there are two components to that action four. There's that short ten-day period of achieving non-negative flows, but then for the remainder of that pre-spawning period, the objective is -- well, the original proposal is a negative 3500 cfs.



THE COURT: Well, the pre-spawning period ends when?

THE WITNESS: What we assumed is that it would end February 20th. That is -- it will vary from year to year when the spawning start -- begins to occur. But February 20th was the date which our biologist provided us, as far as an average spawning date.

THE COURT: But in operation, the plan would go through the actual or through the average date? Spawning?

THE WITNESS: The proposal talks about this action continuing until the onset of spawning. And we had to make some assumption as to when that date of --

THE COURT: Yes. But in operation, would you run the program to this pre-determined date or to the actual date?

THE WITNESS: Oh, we would operate to it until the actual date of spawning.

THE COURT: Which could be different?

THE WITNESS: Which could be different than February 20th.

THE COURT: Thank you. And that's what your calculation is based on.

THE WITNESS: Yes.

THE COURT: Actual date of spawning.

THE WITNESS: Well, no, our calculation is based on -- since we don't know what that date will be next year, we used the average date that has occurred in the past, which is



February 20th.

THE COURT: Thank you.

BY MS. WORDHAM:

Q. Mr. Leahigh, returning your attention to the plaintiffs' -- the first part of plaintiffs' action four, which the flow objective is zero or greater -- zero net negative flows on Old and Middle Rivers. In a dry year, what would be the export reductions associated with the first part of plaintiffs' action four?

A. 140,000 acre feet.

Q. And in an average year?

A. 200,000 acre feet.

Q. Now, turning to the second half of plaintiffs' action four, you have two flow objectives identified here; correct?

A. Yes.

Q. And why do you have two flow objectives identified?

A. Well, there were two different flow objectives identified in the plaintiffs' revised proposal.

Q. The plaintiffs' revised proposal provides a range of between negative 2,750 cubic feet per second and negative 4,250 cubic feet per second; is that correct?

A. That's correct.

Q. Of these -- of this range, which would you characterize as the more water costly flow objective?

A. Well, the more water costly would be the one that is least



negative, which is the negative 2750 cfs.

Q. In a dry year, what would be the water cost associated with plaintiffs' action -- the second part of plaintiffs' action four if the projects were required to operate at negative 2,750 cfs on Old and Middle Rivers?

A. 340,000 acre feet.

Q. Same question for an average year.

A. 680,000 acre feet.

Q. Those costs would be less if they were able to operate at the higher end of that range; is that correct?

A. That's correct.

Q. And those are the 180,000 acre feet and 530,000 acre feet respectively; correct?

A. Correct.

Q. In plaintiffs' action five, they also have a range of flow objectives; correct?

A. That's correct.

Q. If the projects were required to operate to the more water costly flow objective, which I understand from your previous testimony would be the negative 750 cubic feet per second, what would be the water cost associated with plaintiffs' action five in a dry year?

A. Estimate is 350,000 acre feet.

Q. And in a wet year -- in an average year?

A. 920,000 acre feet.

Q. Plaintiffs' action seven has the same flow objective -- range for flow objectives; correct?
A. Correct.
Q. In plaintiffs' action seven, what would be the water cost associated with complying with plaintiffs' action seven if the projects were required to operate at the more water costly flow objective?
A. 150,000 acre feet dry year.
Q. And in an average year?
A. 800,000 acre feet.
Q. For plaintiffs' actions eight and nine, what are the water costs associated with those actions?
A. We didn't have any cost associated with those two actions. They dealt with barrier configuration.
Q. So no water costs?
A. No water costs were estimated for those.
THE COURT: And the response to those two actions was positive or negative, as far as the change of the barriers?
THE WITNESS: Well, the not installing the Head of Old River Barrier would have -- would have a tendency to make the flow at Old and Middle River less negative, would allow more of the San Joaquin flow to come down Old and Middle Rivers.
THE COURT: And are you generally in agreement or disagreement with that proposal?



THE WITNESS: We have a similar -- we have the same recommendation in the Fish & Wildlife Service action matrix.
THE COURT: So that would be agreement?
THE WITNESS: Yes. I'm not sure all the details, but I believe that in general we are in agreement on that.
THE COURT: All right. And how about number nine?
THE WITNESS: I'm sorry. That was number nine.
THE COURT: That was number nine. All right. How about number eight? I think those are the gates.
THE WITNESS: Correct. That would be no ag barrier operation. And there -- there is very similar proposal in the Fish & Wildlife Service Action Matrix.
THE COURT: So there's general agreement on number eight?
THE WITNESS: I'd say there's general agreement. I'm not sure about all the details, but general agreement.
THE COURT: All right. Thank you.
BY MS. WORDHAM:
Q. And turning last to plaintiffs' action ten. You testified -- or you stated in your declaration, as I recall, that your cost estimate for action ten was based on an assumption that action ten would be met through a combination of export reductions and upstream storage releases; correct?
A. That is correct.
Q. With that understanding, what would be the water cost



associated with the projects having to comply with action ten in a dry year?
A. We're still talking about the revised proposal?
Q. Yes.
A. Actually either proposal, it doesn't matter. The dry year -- there's a -- in our analysis, we assume 350,000 acre feet of export reduction, but it would also require 310,000 acre feet of additional releases from upstream.
Q. Would all of that upstream storage come from State Water Project facilities?
A. No. That would -- the assumption that we made is this would fall under the coordinated operation agreement and therefore about two-thirds of it would come from the federal reservoirs, most likely Shasta and a third of it coming from Lake Oroville.
Q. So just looking at export reductions again, for action ten in an average year, if the projects attempted to comply with the plaintiffs' action ten relying on your allocation between export reductions and upstream water storage releases, what would be the water cost to the projects?
A. In an average year, we had estimated 490,000 acre feet export reduction in a small amount of additional releases from upstream.
Q. You testified in your declaration that there isn't a direct correlation or -- between export reductions and



delivery reductions; correct?
A. That's correct.
Q. So in this table immediately below the -- the summary -- or the detailed analysis of the cost, water cost associated with plaintiffs' revised proposal for August 13, 2007. Where you have summarized delivery reductions, the total acre feet, thousands of acre feet that you have there are not going to be the total of the costs in the table above; is that correct?
A. That's correct.
Q. What's the difference between export reductions and delivery reductions?
A. Well, the export reductions would be the immediate impact. Now, how that translates to an overall annual delivery impact will vary on a number of things. In -- for example, in a drier year, there could be an immediate export reduction that could be made up later. So in that case it wouldn't necessarily be according to delivery reduction.
But also, on the flip side, you could have -- in a winter type year, average year, you could have an export reduction that occurs at a very critical time, which in the demand pattern, when demands are peaking, that could actually result in much larger annual delivery impacts. It's rather complicated, but they're not going to match up necessarily.
Q. For purposes of this water cost analysis, how did you

estimate delivery reductions?
A. We -- as I said earlier, we inputted all of these -- well, we input all these export reductions into the DCO model that also has all the constraints of the system. We had our estimates of demand and the demand pattern and we had all of our estimates on hydrology. And the model allows us to simulate the operations and allows us to come up with a bottom line delivery for the entire year.
Q. So if the projects were required to comply with the plaintiffs' revised proposal submitted on August 13th, what did you determine would be the annual export reduction -- annual delivery reductions in a dry year operating under their less water costly proposal? Or range of flow objectives.
A. In a dry year, we -- we calculated 1.11 million acre feet.
Q. And in an average year?
A. 2.56 million acre feet.
Q. So what percent of -- percentage reduction in deliveries does the 1.117 million acre feet represent?
A. It represents a 35 percent reduction from our baseline delivery.
Q. And what percentage reduction does the 2.557 million acre feet represent?
A. 43 percent reduction from our baseline delivery.
Q. If the projects were required to operate to the most water



costly flow requirements of the plaintiffs' revised proposal, what would be the annual delivery reductions in a dry year?
A. 1.62 million acre feet.
Q. And what percentage of the delivery reductions does that represent?
A. 50 percent reduction in baseline delivery.
Q. And in an average year, what would be the acre foot reduction?
A. 3.57 million acre feet.
Q. And what percentage in delivery reductions does that represent?
A. 60 percent.
MS. WORDHAM: Thank you. At this time, Your Honor, rather than walking the witness through each of the tables for each of the proposals, I would like to mark as DWR Exhibit M, I believe --
THE COURT: N as in Nancy.
MS. WORDHAM: N.
(Defendant's Exhibit DWR N was marked for identification.)
THE COURT: After that's marked, we're going to take a ten-minute recess because we're going to go until 12:30 today because I have a short proceeding at 1:15. So our noon break is going to be 12:30 to 1:15.
MS. WORDHAM: Yes, Your Honor.



THE COURT: You know what? We've got a 10:30 proceeding as well. Okay. We're going to go until 10:30.
MS. WORDHAM: For purposes of identification, this is a table entitled Estimated Total 2008 State Water Project and Central Valley Project Delivery Reductions Associated with Interim Remedy Proposals.
MS. JAISWAL: Plaintiffs have not received it.
THE COURT: Beg your pardon?
MS. JAISWAL: I have not received the exhibit.
THE COURT: You now have?
MS. JAISWAL: Yes, Your Honor.
MS. WORDHAM: May I approach?
THE COURT: Yes.
BY MS. WORDHAM:
Q. Mr. Leahigh, do you recognize this table that I have now handed you?
A. Yes.
Q. Marked as DWR Exhibit N.
A. Yes.
Q. Does this table accurately summarize the water cost you had estimated for each of the remedy proposals that have been submitted in this proceeding?
A. Yes, I believe so.
MS. WORDHAM: At this time, Your Honor, I'd like to move DWR Exhibit N into evidence.



THE COURT: Any objection?
MS. JAISWAL: Continuing objection, Your Honor.
THE COURT: All right. Exhibit N is received in evidence. It appears simply to be a summary of the compilation of the cumulative totals of the underlying Exhibits I through M, therefore it's subject to the same ruling on the plaintiffs' objections.
(Defendant's Exhibit DWR N was received.)
MS. WORDHAM: Your Honor, did you wish to take a break at this time?
THE COURT: No. We have a proceeding at 10:30, so we're going to go until 10:30 and the court reporter is going to take a break then.
MS. WORDHAM: Thank you.
Q. Mr. Leahigh, if you will look at the left-hand column of this table. What is the caption across the top?
A. "Proposals."
Q. And underneath that, does it list the various proposals that have been submitted in this matter?
A. Yes, it does.
Q. And then the columns next to that, please describe them.
A. Yes. There's two columns, one that takes a look at the average year cost and the dry year cost. And it breaks it down in terms of the cost in acre feet, delivery reductions in acre feet and the percent that that represents from baseline

operations for both average and dry years.
Q. You have mentioned baseline operations a couple of times now. Could you please define what you mean by "baseline operations"?
A. Yes. Baseline operations, as I'm using it here, would be the delivery capabilities of both projects absent the implementation of any of the proposals. So in an average year, that's a combined of 5.9 million acre feet, I believe; and in a dry year, it's 3.2 million acre feet.
Q. Under the proposals, the first proposal is the US Fish & Wildlife Service Action Matrix or USFWS Action Matrix; correct?
A. Correct.
Q. And you have -- are you familiar with the US Fish & Wildlife Service Action Matrix?
A. Yes.
Q. Beneath the title "USFWS Action Matrix" are the words "upper range" and "lower range." Would you briefly explain what those refer to?
A. Yes. As part of the US Fish & Wildlife Service proposal, a couple of the actions, specifically three and four, although the process is very specific, it allows for a range of protective objectives at Old and Middle River. And so we -- in order to come up with the potential delivery impacts, we analyzed the proposal at both the upper range and the lower



range of those Old and Middle River objectives.
Q. So would it be fair to say that the upper range represents the more restrictive flow objectives and therefore the more cost -- water costly proposal?
A. Yes.
Q. And does the same hold true for the Fish & Wildlife Service action matrix as revised by the Department of Water Resources?
A. That's correct.
Q. And is this the same type of range that the plaintiffs included in their revised remedy proposal?
A. Well, the plaintiffs provided a range in their revised proposal. It's -- and so we analyzed it using each of the objectives indicated in that revised proposal.
Q. If the projects were required to implement the US Fish & Wildlife Service action matrix using the most restrictive flow objectives on Old and Middle Rivers, what would be the total impacts to the Central Valley Project and State Water Project?
A. I'm sorry, this is for the US Fish & Wildlife Service proposal?
Q. Yes.
A. That's --
Q. In an average year.
A. 2.17 million acre feet.
Q. And what percentage loss of delivery, water delivery does



that represent?
A. 37 percent.
Q. And in the lower -- if they were required to implement the US Fish & Wildlife Service action matrix using the less restrictive flow objectives, what would be the total impacts in an average year?
A. 820,000 acre feet.
Q. And what would be the percentage of loss --
A. 14 percent.
Q. -- in water deliveries?
Under the US Fish & Wildlife Service action matrix as modified by the Department of Water Resources, what would be the total impacts to the State Water Project and Central Valley Project if they were required to operate under the most restrictive flow objectives?
A. In a dry year, 814,000 acre feet. Or 25 percent reduction.
Q. Actually I'm referring now to the --
A. Oh, I'm sorry. You moved to the DWR's modification?
Q. Yes.
A. I'm sorry. Under DWR's modification to the Fish & Wildlife Service action matrix, under an average year, the -- in the most restrictive range, the cost would be 1.41 million acre feet.
Q. And in the lower range?



A. 476,000 acre feet.
Q. Now, in a dry year, the water delivery costs appear to be less; is that correct?
A. That's correct.
Q. And why would that be?
A. That's because the baseline deliveries are substantially less. And that's due to hydrology, just the water supply not being there, not being available.
Q. You have also estimated a water cost associated with the proposal of the State Water Contractors tier one; is that correct?
A. Yes.
Q. And you --
THE COURT: If you don't mind.
MS. WORDHAM: Beg your pardon?
THE COURT: Let me go back to these two answers that you gave. If you have, under the DWR revised proposal, I'm looking at the middle of Exhibit N and I don't find the figure that you mentioned. Is it on this exhibit? Or are you giving me that from some other source?
THE WITNESS: As far as the impacts --
THE COURT: Yes.
THE WITNESS: -- associated --
THE COURT: With the 1,400,000 dollar -- I'm sorry, 4 00,000 acre foot reduction.

THE WITNESS: Correct. That's on the exhibit. Under "upper range" under "average year."
THE COURT: I see. It just doesn't say "average year."
THE WITNESS: "Average year" at the top of the column.
THE COURT: There. I see. All right. Thank you.
BY MS. WORDHAM:
Q. Mr. Leahigh -- I apologize. May I continue?
THE COURT: Yes, you may.
BY MS. WORDHAM:
Q. Mr. Leahigh, these totals that are listed in this table are taken from your Exhibits F and C, which have been marked as DWR Exhibits L and K; is that correct?
A. That's correct.
Q. With the exception of the estimate for the State Water Contractors proposal?
A. Yeah. Actually with the exception of the revised plaintiffs' proposal and the tier one, Hanson tier one proposal.
Q. And the plaintiffs' revised proposal -- numbers for the plaintiffs' revised proposal come from DWR Exhibit M, the table that you authenticated earlier; is that correct?
A. That's correct.
Q. Going back to the Hanson tier one proposal. It states



here that you estimated that with Q west. Can you briefly describe what that means?
A. Yes. The tier one proposal essentially calls for non-negative flows on the lower San Joaquin River just before the confluence with the Sacramento River. And actually there is a parameter of Q west as an equation, a thresh equation that's been developed in order to essentially estimate that exact same thing.
So that equation takes into account inflows into the Delta, export rates and consumptive use in that -- in that part of the Delta and gives us an estimate for that flow, net flow on the lower San Joaquin River.
Q. In estimating the water delivery impacts from the Hanson tier one proposal, did you use the Delta coordinated operations model?
A. Yes, we did.
Q. What would be the total impacts to the Central Valley Project and State Water Project in an average year if the projects were required to implement the state water contract tier one proposal?
A. The estimate is 316,000 acre feet.
Q. And what percentage reduction in delivery, water deliveries does that represent in an average year?
A. Five percent.
Q. You testified that these percentages of reduction in water



deliveries is from a baseline; correct?
A. Correct.
Q. And in an average year, the baseline would be 5.9 million acre feet; correct?
A. Correct.
Q. So under the plaintiffs' revised proposal, if the projects were required to operate to the most restrictive flow level, meaning the most water costly flow level, of the 5.9 million acre feet baseline, how much would the projects be able to deliver?
A. Well, the difference between the 5.9 and 3.6. So 2.3.
Q. And in a dry year, if the projects were required to operate to the most restrictive of the plaintiffs' flow requirements in their revised proposal, from baseline of 3.2 million acre feet, how much would the projects -- how much water would the projects be able to deliver?
A. 1.6.
Q. Thank you. Mr. Leahigh, are you familiar with the Environmental Water Account?
A. Yes.
Q. Will you briefly describe your understanding of the Environmental Water Account?
A. Yes. The Environmental Water Account came about as part of the science the CALFED brought back in 2000 and it's a program that provides for the purchase of water assets to be



applied towards primarily export reductions for the protection of fish. And it's managed by five agencies, Department of Water Resources, Bureau of Reclamation, US Fish & Wildlife Service, Department of Fish & Game and NOAA Fisheries.
Q. When you were estimating your water costs associated with the various remedy proposals submitted in this matter, did you take into consideration the availability of water under the Environmental Water Account?
A. No. This -- these costs do not account for any mitigation that might be possible with the Environmental Water Account.
Q. Why is that?
A. Well, partly because at the time that we first put these proposals together, the financing for the Environmental Water Account was shaky at best for next year. I think another reason is it's not entirely clear how Environmental Water Account would be applied towards these -- Environmental Water Account water could be used for both protection of Chinook salmon as well as delta smelt. It's not entirely clear how this -- how it would be applied to any possible remedy.
Q. Do you have any idea how much water is generally available under the Environmental Water Account?
A. Yeah, typically the purchased amounts are between 200 and 250,000 roughly acre feet. In addition, there are opportunities under flexible operations for possibly another 100,000 acre feet or so.

Q. In your opinion, if the projects had access to Environmental Water Account water for the coming water year, would that significantly reduce the water costs associated with the various remedy proposals?
A. Well, to a certain extent it could mitigate the costs of -- it would mitigate, most likely, the costs of these proposals. Although the magnitude of these costs is, as you can see, for some of the more extreme costly proposals is -- you know, the full 300,000 would be a mere ten percent of the total cost of the most expensive proposal here.
Q. Mr. Leahigh, are you familiar with something that is sometimes referred to as B2 water?
A. Yes.
Q. Can you briefly describe your understanding of B2 water?
A. Well, B2 water does fall under the CVPIA that we -- that the Court mentioned earlier. It is a federal program that allows for the use of CVP supply of 800,000 acre feet from year to year for fishery protection.
Q. Did you take the availability of B2 water into consideration when estimating your water costs associated with the various remedy proposals?
A. No. Did not.
Q. And why not?
A. Well, as I said, this is a -- this is a federally run program. It has quite a complicated accounting system, which



we do not have the expertise to implement in our model. So we did not make an attempt to try to analyze how B2 might be applied to any remedy.
I mean, just in general, we do know that -- the amount of 800,000 that's available varies from year to year. Much of that 800,000 is applied to meeting the baseline standards, which is the D 1641. And I do know that in general, in dry years, there's typically -- there typically -- most or all of the 800,000 is used just to meet those baseline requirements.
So, for example, this year, essentially the entire 800,000 was used to meet the 1641 objectives and there would be nothing available to meet any remedy proposal.
THE COURT: Did you give any consideration to the provisions of B2 that refer to ESA and other requirements under state and federal law as to what applicability, if any, that would have to this, the issues here?
THE WITNESS: No.
BY MS. WORDHAM:
Q. Mr. Leahigh, are you familiar with the declarations submitted by Mr. Spreck Rosekrans in this proceeding?
A. Yes.
Q. I think these have been identified as plaintiffs' Exhibits 24 and 25.
Have you looked at Mr. Rosekrans' methodology for



determining water costs associated with the various remedies?
A. Yes.
Q. Does Mr. Rosekrans' methodology differ from the one that you used?
A. Yes. Very much so.
Q. Would you please explain how.
A. Well, as we reviewed earlier, we actually took a projection of next year's operations in order to determine -- estimate the delivery impacts. So we took into account such things as the estimate of the delivery demand patterns, the supply that's available, including carryover storage in reservoirs and the current regulatory environment that we're operating to.
Whereas Mr. Rosekrans took a look at historical operations and tried to apply these proposed -- his -- the plaintiffs' proposed remedy on to that historical data. So he actually did not model next year's operations.
And there's a number of -- one of the problems with that is there's a number of years that he analyzed the demand patterns to be quite different. The land use patterns upstream of the Delta, which affects the inflow would be quite different; the regulatory environment as far as the Bay-Delta standards would be quite different in most of those years; the beginning storages in the system that we have a good prediction of going into next year would be different in every



single one of those years than the unique set of circumstances we have this year.
So I believe our estimates would be much more reliable, as far as estimating the impacts into next year.
Q. Are there any other differences in your assumptions than Mr. Rosekrans' assumptions in estimating water supply impacts?
A. Yeah. There was another key difference as far as the assumption on the extent of the plaintiffs' action seven on how long that action would take place. Mr. Rosekrans assumed that that action would end June 15th.
In our analysis, we assumed it would end July 15th. And the reason we assumed July 15th was that this was five days beyond the average observation of delta smelt in salvage at the fish facilities. And that is the triggering mechanism identified in the plaintiffs' proposal for the end of action seven.
Now, this additional 30 days that we assumed for this implementation of this objective is critical, that 30-day period from June 15th to July 15th represents the peak of the demand, of the water demand on the system on both projects. So this really created a choke point in our delivery capability for the project.
Essentially meeting that objective would require us to minimize our exports during that 30-day period whereby we would have to meet the entire supply out of San Luis Reservoir

south of the Delta. There are limitations, physical limitations on how quickly we can withdraw water from San Luis Reservoir.

So in many cases we would not be able to meet the demand that occurred in that critical period.

Q. Mr. Leahigh, do you know why Mr. Rosekrans selected June 15th as their end of action?

A. Well, the triggering --

MS. JAISWAL: Objection.

THE COURT: I'm assuming that you're objecting on the ground of lack of foundation. And so you may lay the foundation.

MS. JAISWAL: Yes, Your Honor. And calls for speculation.

THE COURT: That is subsumed within my ruling.

BY MS. WORDHAM:

Q. Mr. Leahigh, is there any explanation in Mr. Rosekrans' declaration for why he selected June 15th as the date for estimating the end of action, of the plaintiffs' action seven, I believe.

A. Well, June 15th is identified as the end of action seven or the last detected delta smelt at the fish facilities, with whichever comes later.

I believe that in Mr. Rosekrans supplemental declaration, he talks about the justification for June 15th in



that he refers to Dr. Swanson's declaration that the taking of actions, taking of actions earlier in the year would influence how late into the year we would detect delta smelt at the facilities. So I think that's what he stated as his, if I understand it correctly, his reasoning for using June 15th.

Q. And if you will look at Plaintiffs' Exhibit 4, which should be somewhere in front of you there. It is the declaration of Christina Swanson filed on August 13th. Document No. 466-2. Do you have that?

THE COURT: Before you go on to this, let me ask a question. What is your analysis of the time frame that Mr. Rosekrans establishes there as opposed to the period that you have utilized for the combined operation response?

THE WITNESS: For action seven? For the end --

THE COURT: For action seven, yes.

THE WITNESS: What we did was we took a look at the historical salvage in each year, since '93. And what we did was we used the median of all those last dates of salvage detected at either facility, which turned out to be July 10th. The triggering -- the language for the trigger talks about five days beyond the last detected smelt, so that's why we used July 15th in our analysis. And there's --

THE COURT: Go ahead.

THE WITNESS: I was going to say, there's -- I mean, as far as the reasoning given by Mr. Rosekrans, there have



been a number of years in the past, wet years where we would have seen Old and Middle River flows at least meeting the objectives of the plaintiffs earlier in the year, if not more positive than the objectives proposed by the plaintiffs. But yet, many of those years, in fact most of those years, we saw salvage at the facilities into July. So I feel that our -- our assumption is the correct one.

THE COURT: Thank you. Did you have a question?

MS. WORDHAM: Yes, Your Honor.

Q. Mr. Leahigh, if you would turn to page 31 of Dr. Swanson's declaration, paragraph 38.

A. Got it.

Q. I'm going to read, beginning line 27.

"Based on particle tracking modeling and statistical relationships between Old and Middle reverse and take of adult delta smelt, these conditions" -- and I will say these are referring to conditions on Old and Middle River for the plaintiffs' action seven -- I won't make that representation because I'm afraid I'm going to misrepresent what all of paragraph 38 says.

MR. WILKINSON: Start over, please.

BY MS. WORDHAM:

Q. I think I'll start over from the beginning of paragraph 38.

"Mr. Leahigh's analysis of water cost for



implementation of the plaintiffs' recommended interim protection actions includes the assumption that salvage of juvenile delta smelt would continue through mid July." And then cites to Leahigh reply declaration at paragraph 24.

"He basis this on examination of historical salvage of delta smelt since 1993, which shows that in half of those years seasonal salvage of young delta smelt ended on July 10. However, during that period, reverse flows on Old and Middle Rivers averaged negative 3,265 cubic feet per second in June with a range of negative 8,853 to 8,747 and negative 7,760 cfs in July with a range of negative 897 to negative 10,819 cfs. Based on Particle Tracking Model and statistical relationships between Old and Middle reverse and take of adult delta smelt, these conditions correspond to high rates of entrainment of fish into the central and south Delta and into CVP and SWP fish salvage facilities. Under the much lower reverse flow conditions for Old and Middle Rivers specified in plaintiffs' action seven and the preceding months (i.e., plaintiffs action five and six) it is likely that the movement of young delta smelt from the Delta channels and sloughs where they were hatched to downstream rearing areas near the

1 confluence and in Suisun Bay and beyond the influence
2 of the export pumps would have been improved and few
3 or no fish would remain in the south Delta as late as
4 July."
5 Mr. Leahigh, attached as Exhibit D to your August 3,
6 2007 declaration, which has been marked as DWR Exhibit F is a
7 table entitled "Analysis of Last Date of Delta Smelt Salvage
8 by Banks PP and Jones PP." Do you have that document in front
9 of you?
10 THE WITNESS: Yes. Yes, that's -- is that DWR
11 Exhibit J?
12 Q. DWR Exhibit F. It's a one-page table and it's Exhibit D
13 to your supplemental declaration.
14 A. Oh, okay. Yes. I have it.
15 Q. You have that?
16 A. Yes.
17 Q. Mr. Leahigh, looking at year 1996, what type of year was
18 that?
19 A. That was a wet year.
20 Q. And in 1996, how wet was it?
21 A. 1996?
22 Q. Well --
23 A. 1990 -- well --
24 Q. Perhaps I mean 1998.
25 A. Yes. 1998 was the last big El Nino year, so it was



1 a -- on the wetter side of wet, extremely wet year. In fact,
2 we were curtailed at the exports for long periods of time in
3 the spring, for a good deal of the spring. There was flooding
4 going on in the San Joaquin basin. We actually had some flows
5 actually coming in to the aqueduct rather than making
6 deliveries. So we were shut down for most of -- or long
7 periods during the spring. Old and Middle River flows were,
8 in fact, positive from the end of February all the way through
9 the middle of July.
10 THE COURT: All right. We're going to take the
11 morning recess at this time. We'll stand in recess until 15
12 minutes before 11.
13 MS. JAISWAL: Your Honor, if we could just get some
14 direction for the Court for the schedule for today. Given
15 that we are at 10:30.
16 THE COURT: We're going until 12:30 and we're going
17 to resume at 1:30 and we'll be going at least until five, I
18 presume. We're in recess until 10:45.
19 (Recess.)
20 THE COURT: We're going back on the record in NRDC
21 versus Kempthorne. And we're going to continue Mr. Leahigh's
22 testimony.
23 Mr. Wordham, you may proceed.
24 BY MS. WORDHAM:
25 Q. Mr. Leahigh, before the break we were looking at DWR



1 Exhibit F, which I believe is Exhibit D to your August 3, 2007
2 declaration. Do you have that in front of you?
3 A. Yes, I do.
4 Q. And you had just described the water year 1998 as a very
5 wet year; is that correct?
6 A. Yes.
7 Q. And it was so wet, in fact, I believe you testified that
8 there were positive flows on Old and Middle Rivers from
9 February through July of that year; is that correct?
10 A. That's correct.
11 Q. And it was so wet that there were periods of time when the
12 projects were not even pumping; is that correct?
13 A. Yes. As far as State Water Project, there were long
14 periods of time we were not pumping.
15 Q. In 1998, what was the last date of salvage taken by either
16 the State Water Project or the Central Valley Project?
17 A. July 10th.
18 Q. Going back to paragraph 38 of Dr. Swanson's August 13,
19 2007 declaration. In your opinion, given the conditions that
20 existed in 1998 and the last date of salvage for 1998, in your
21 opinion is it possible that fish may -- smelt may be salvaged
22 at the Jones or Banks Pumping Plants after June 15th --
23 MS. JAISWAL: Objection.
24 MS. WORDHAM: If I may finish the question.
25 MS. JAISWAL: I'm sorry. I thought you were done.



1 BY MS. WORDHAM:
2 Q. -- even if plaintiffs' actions five, six and seven were
3 implemented?
4 A. That's what the historical data seems to indicate, yes.
5 Q. Thank you. We have been talking about Dr. Swanson's
6 August 13 declaration. You are familiar with this
7 declaration?
8 A. Yes.
9 Q. Are you familiar with the plaintiffs' proposed action ten
10 of their remedy proposal?
11 A. Yes, I am.
12 Q. Would you please briefly describe your understanding of
13 their action ten?
14 A. Yes. Action ten requires that the X2 line or two parts
15 per thousand salinity be maintained at 80 kilometers from the
16 Golden Gate or three-day outflow of 7500 cfs to be maintained
17 for the period from September 1st through December 15th.
18 Q. If you look at paragraph 21 of Dr. Swanson's August 13
19 declaration, which is Plaintiffs' Exhibit 4, on page 19. At
20 the bottom of page 19, Dr. Swanson -- in paragraph 21, Dr.
21 Swanson states that, "The projects can -- well, let me read
22 all of paragraph -- the first part of paragraph 21.
23 "There are at least three strategies that can be
24 employed singly or in combination by the state and
25 federal water projects to modify operations to

maintain Delta outflows at the levels that protect delta smelt critical habitat as proposed in plaintiffs' action ten without causing potential adverse impacts on listed salmonid species on the Sacramento River. First, the projects can reduce Delta export rates."

In your opinion, Mr. Leahigh, do you believe that the projects could meet the outflow requirements of plaintiffs' action ten strictly through export reductions?

A. In most years, we wouldn't be able to meet it through export reductions without some kind of impact to San Luis Reservoir.

Q. What would be those impacts?

A. They would be in terms of water quality and slope stability.

Q. And what would be the water quality impacts?

A. The water quality impacts are essentially, when you get down to the last ten to 15 percent of storage in San Luis Reservoir, all of the impurities in the water are consolidating. For example, you get the blue-green algae that's on the surface at that storage, low storage level, it's within -- starts to be brought into the intakes, into the San Felipe diversion, which is Santa Clara Valley Water District's diversion, which diverts directly out of San Luis Reservoir.

Q. At what point would you start experiencing these water



quality impacts?

A. Yes. This would be at about 300,000 acre feet and below is where you start to see those type of impacts.

Q. So once the storage level reaches about 300,000 acre feet, then you start experiencing these water quality impacts?

A. That's correct.

Q. What's the current storage level in San Luis Reservoir?

A. Current storage as of midnight last night was about 470,000 acre feet.

THE COURT: What is the capacity?

THE WITNESS: Capacity is a little over 2 million acre feet.

THE COURT: And what is the normal storage as of August 31st historically in the San Luis Reservoir?

THE WITNESS: As of August 31st, if you were to look back at the historical record, it's probably a bit higher than we are now. Although typically this is -- this is when we hit the low point in San Luis. This is when it is at its lowest point. This is the end of the agricultural season.

THE COURT: Thank you.

BY MS. WORDHAM:

Q. You have testified, I believe, Mr. Leahigh, that this current water year we are in, which ends at the end of September, is a dry water year; is that correct?

A. Yes.



Q. And that the conditions in the Sacramento and San Joaquin basins are dry; is that correct?

A. Yes. Dry. In fact, critically dry in the San Joaquin basin.

Q. And do you expect those conditions to continue into the fall?

A. Well, those conditions would continue until we get the first big rains of the year, which nobody knows when that will occur. But typically, the earliest we see significant precip, end of October possibly, but could be as late as into January or possibly in critically dry years, you don't see much of an event at all as far as precip.

Q. If the Department of Water Resources and the Bureau of Reclamation were required to implement plaintiffs' action ten and meet the flow objectives of plaintiffs' action ten strictly through export reductions, would the water level in San Luis Reservoir reach 300,000 acre feet this fall?

A. It's likely that we would reach that storage level before the end of October.

Q. If the projects were to implement plaintiffs' action ten solely through export reductions, but not impact San Luis Reservoir to the point of reducing the level of San Luis Reservoir to 300,000 acre feet or below, would that result in significant water delivery impacts to water contractors?

A. I'm sorry. Can you restate the question?



THE COURT: Read it back, please.

(Record read as requested.)

THE WITNESS: Yes.

BY MS. WORDHAM:

Q. Have you quantified that amount of that impact?

A. Yeah. We estimated that it would be on the order -- well, let's see, in order to maintain San Luis at 300,000 acre feet, and all of the delivery -- I mean, all of the -- action ten is met strictly through export reductions, would require delivery reductions of two to 300,000 acre feet in a short period of time. We're talking the next two months.

Q. And you testified that another impact of San Luis Reservoir could be structural stability; correct?

A. Correct.

Q. And what is that structural stability issue?

A. Well, we took a look at -- we analyzed if we were to meet action ten strictly through export reductions, what kind of draw down rates we would be looking at in San Luis Reservoir in order to meet -- because exports would be very low. All of the demand would be coming out of San Luis Reservoir. Those draw down rates would be on the same order as those that were experienced back in 1981 when we had a major slide on the inside face of Sisk Dam at San Luis Reservoir. That this would require taking the reservoir out of service, it was completely drained and repairs took about a year to repair the

1 damage. And we would anticipate if we saw a similar type
2 failure, we would anticipate similar type outage.
3 Q. Referring back to Plaintiffs' Exhibit 4, which is the
4 Christina Swanson declaration. And again looking at paragraph
5 21. Now on page 20. At line seven, Dr. Swanson states that
6 "The CVP and the SWP could increase releases from their other
7 upstream reservoirs, including Oroville, Folsom and New
8 Melones instead of relying so heavily or exclusively on Shasta
9 Reservoir" as one means of implementing plaintiffs' action
10 ten. Do you see that?
11 A. Yes.
12 Q. In your supplemental declaration, you stated that one
13 means of managing the projects if plaintiffs' action ten were
14 implemented would be by a combination of reducing
15 storage -- exports and releasing water from storage; correct?
16 A. Correct.
17 Q. How much water did you anticipate that the projects would
18 need to release from storage to implement plaintiffs' action
19 ten?
20 A. We analyzed it a couple of ways. In my declaration, it
21 was assumed that under dry conditions, about 300,000 acre feet
22 would be required from upstream in order to meet it. In order
23 to avoid any impacts that we just discussed at San Luis
24 Reservoir, we would require something closer to 500,000 acre
25 feet from upstream.



1 Q. Is that the same estimate that Mr. Milligan -- let me
2 rephrase. Or let me strike that and start over.
3 Are you familiar with the declaration of Ronald
4 Milligan that was filed by the federal defendants in this
5 matter?
6 A. Yes.
7 Q. Did Mr. -- Mr. Milligan, in his declaration, estimated
8 that under dry conditions and the forecasted reservoir levels,
9 export releases of up to 500,000 acre feet would be required
10 to implement plaintiffs' action ten. Is that the level of
11 releases that you're referring to?
12 A. Yes. That --
13 MS. JAISWAL: Your Honor, I'd like to restate our
14 continuing objection.
15 THE COURT: All right. And the ruling is the same.
16 BY MS. WORDHAM:
17 Q. Mr. Leahigh.
18 A. Yes. That figure that Mr. Milligan quoted is consistent
19 with our analysis in how much water would be required from
20 upstream in order to avoid impacts at San Luis Reservoir in
21 dry conditions.
22 Q. And the 310,000 acre feet that you estimated would
23 be -- should be released to manage the projects if the
24 plaintiffs action ten were implemented with a combination of
25 export reductions and upstream releases could have an impact



1 on water quality in San Luis Reservoir; is that correct?
2 A. Yes. If we operated under dry year conditions as laid out
3 in my declaration, it shows 300,000 necessary from upstream.
4 But San Luis does drop well below that 300,000 mark in that
5 particular analysis.
6 MS. WORDHAM: At this time, Your Honor, I'd like to
7 mark as DWR next, I think it's O. This is an excerpt from the
8 Biological Opinion on the long-term Central Valley Project and
9 State Water Project operations criterion plan, which I believe
10 is the subject of litigation in a companion case, PCFFA versus
11 Gutierrez, which is case number 06-CV-00245.
12 THE COURT: It will be marked for identification DWR
13 Exhibit O.
14 (Defendant's Exhibit DWR O was marked for
15 identification.)
16 MS. WORDHAM: I'd also like to mark as DWR Exhibit P
17 an agreement between the Department of Water Resources and the
18 Department of Fish & Game concerning the operation of the
19 Oroville division of the State Water Project for management of
20 Fish & Wildlife.
21 (Defendant's Exhibit DWR P was marked for
22 identification.)
23 MS. WORDHAM: And last, for the time being, I would
24 like to mark as DWR Exhibit Q, if I remember my alphabet
25 correctly, a US -- United States Federal Energy Regulatory



1 Commission order amending a Federal Energy Regulatory
2 Commission license.
3 (Defendant's Exhibit DWR Q was marked for
4 identification.)
5 MS. WORDHAM: If I may approach?
6 THE COURT: Yes, you may.
7 BY MS. WORDHAM:
8 Q. Mr. Leahigh, I have just handed you three documents which
9 have been marked as Exhibits DWR O, DWR P and DWR Q. Looking
10 at the first document, Exhibit DWR O, do you recognize this
11 document?
12 A. Yes.
13 Q. Can you briefly describe it?
14 A. Well, this is an excerpt from our Biological Opinion for
15 long term operations for both Central Valley Project and State
16 Water Project Operations Criteria and Plan or OCAP.
17 Q. Is this a complete copy of the Biological Opinion?
18 A. No. This is an excerpt.
19 MS. WORDHAM: Your Honor, at this time I would like
20 to request that the Court take judicial notice of the complete
21 Biological Opinion, which is on file in the related case,
22 PCFFA versus Gutierrez.
23 THE COURT: Any objection?
24 MS. JAISWAL: Your Honor, we are objecting on grounds
25 of completion for the document.

THE COURT: The request was just made that I take judicial notice of the entire Biological Opinion, which would include this document. Any objection to that?

MS. JAISWAL: No, Your Honor.

THE COURT: The request for judicial notice is granted. And I will -- if you tell me what part you want me to look at, if there's anything more than this, I will refer to the OCAP BiOp as the subject of case number 06-CV-00245.

BY MS. WORDHAM:

Q. Mr. Leahigh, to your knowledge, does the Biological Opinion for the long-term -- strike that.

Mr. Leahigh, do you know what bio -- what species are addressed in this Biological Opinion that we are now referring to?

A. Yeah. What I failed to mention is this is the Biological Opinion issued by National Marine Fisheries Service, so it covers Chinook salmon and steelhead spring-run -- more specifically spring-run Chinook salmon and steelhead.

Q. Are these species listed under the Endangered Species Act?

A. Yes.

Q. Do you know if they're listed as threatened or endangered?

A. I believe it's threatened.

Q. To your knowledge, does this Biological Opinion require that DWR maintain water temperatures on the Feather River at certain levels for protection of the spring-run and steelhead?



A. Yes.

Q. If I may turn your attention now to DWR Exhibit P. Are you familiar with this document?

A. Yes, I am.

Q. Would you please briefly describe it.

A. This is an agreement, an operating agreement between Department of Water Resources and Department of Fish & Game. Dated August 1983. And it has numerous provisions in it related to minimum instream flow requirements downstream of the Oroville complex on the Feather River. Also includes ramping criteria, change in those releases and also flow stability provisions where once a certain level of habitat is established at a certain level of flow, that those flows need to be maintained for a period of time.

Q. How is it that you are familiar with this particular document?

A. Well, it's -- it's essential that in order to operate the project, that we are familiar with this. These are the conditions on which we operate the project. The -- these provisions are -- as far as the minimum flow requirements, are built into our operations model that analyzes the operations and the delivery capabilities.

MS. WORDHAM: Your Honor, at this time I would like to move DWR Exhibit P into evidence.

THE COURT: Any objection?



MS. JAISWAL: Completion, Your Honor.

THE COURT: This appears to be a stand alone agreement. The objection is overruled. Exhibit P of DWR is received in evidence.

(Defendant's Exhibit DWR P was received.)

BY MS. WORDHAM:

Q. Mr. Leahigh, is the State Water Project required to operate to any specifications set forth by the Federal Energy Regulatory Commission?

A. Yes. The FERC license covers all operations of the Oroville complex. It has actually incorporated the flow provisions that are in this agreement between the Fish & Game and DWR.

Q. Would you turn your attention to DWR Exhibit Q. Are you familiar with this document?

A. Yes.

Q. Would you please briefly describe this document.

A. Well, this is the order amending our license, our FERC license, and this does incorporate these flow provisions from the Fish & Game agreement into our FERC license.

Q. So you are required to comply with the provisions of this order in operating Oroville Reservoir?

A. Yes.

MS. WORDHAM: Your Honor, at this time I would like to move DWR Exhibit Q into evidence. Any objection?



MS. JAISWAL: Your Honor, it appears we have pages one, two and five for this document. I'm not sure if this is a copy error or if it is not complete.

THE COURT: That does appear to be the case. Did you just omit a couple of pages?

MS. WORDHAM: Well, if I have, I've omitted them from all the copies I have here today, Your Honor.

THE COURT: Was that intentional or just inadvertent?

MS. WORDHAM: It was inadvertent.

THE COURT: All right. Well, what I'll do is this. Subject to your adding the two pages that are not present, I'll admit Exhibit Q into evidence.

MS. WORDHAM: I will make sure that the missing pages are provided to the Court and all parties as soon as possible, Your Honor.

THE COURT: Thank you very much.

(Defendant's Exhibit DWR Q was received.)

Q. Mr. Leahigh, is the Department of Water Resources, at its Oroville Reservoir facility, required to comply with the various flow restrictions and temperature restrictions that you just described in each of these documents?

A. Yes.

Q. This is a legal requirement?

A. Yes.

Q. Now, if the projects, being both the State Water Project

and the Central Valley Project, were required to implement the plaintiffs' action ten by releasing water only from Lake Oroville, would that have an effect on DWR's ability to meet the flow restrictions and water temperature restrictions that you've just described in these documents?
A. Yes. Very much so.
Q. And how is that?
A. If we were required to meet -- if I understood your question correctly, if we were required to meet the Delta ten action solely, that the upstream portion of that, from Lake Oroville, there would be extreme impacts to Oroville storage. Most notably due to the provision three of the agreement with Fish & Game as far as having to provide releases above the threshold release identified in provision three.
Once that higher flow is established, we must maintain that higher flow from the fall through March of the following spring.
This would have a devastating effect on Lake Oroville storage and it would severely compromise our ability not only to meet the temperature requirements the following year, but most likely it could very well have impacts if this following winter is dry or critically dry on our ability to meet even our share of Delta requirements.
Q. By "Delta requirements," you mean the water quality standards and flow requirements of --



A. The flow standards, salinity standards for Fish & Wildlife purposes and agricultural uses, yes.
Q. Why would you be required to maintain such high flows from -- high release rates from Lake Oroville? What would be the purpose of maintaining those releases?
A. Well, the reasoning behind it is that once we make releases at the higher level, we establish new habitat for Chinook and steelhead in the Feather River. In order to avoid dewatering redds or straining fry later in the season, we have to maintain that same level of habitat. So thereby maintaining that same level of release through the spring of the following year.
Q. So these higher flows are intended to protect endangered species; is that correct?
A. That's correct. All species, including endangered species.
Q. Do you have any option -- any alternative to maintaining these flows --
A. No.
Q. -- at these higher --
A. It's in our legal requirements, it's in our agreement with Fish & Game and it's also legally binding in our FERC license.
Q. So the only way that you could avoid those impacts that you just described would be to violate your regulatory requirements under the FERC license, under the Fish & Game



agreement and as imposed by the biological opinions that we were just discussing; is that correct?
MS. JAISWAL: Objection, Your Honor.
THE COURT: Ground?
MS. JAISWAL: Assumes fact not in evidence.
THE COURT: Overruled. You may answer.
THE WITNESS: Yes.
BY MS. WORDHAM:
Q. Mr. Leahigh, in the remedies proposed by the US Fish & Wildlife Service and the Department of Water Resources -- you're familiar with all of those remedy proposals; correct?
A. Yes.
Q. There's certain actions that require the Old and Middle River flows to be maintained at a certain rate; is that correct?
A. That's correct.
Q. And this level is achieved by averaging flows over a period of days; correct?
A. That's correct.
Q. And what is that averaging period?
A. Well, the averaging period -- oh, in the Fish & Wildlife Service proposal specifically?
Q. Yes.
A. Is that what you're --



Q. I'll start with them.
A. It requires it to meet it on -- the objective on a 14-day average, less restrictive -- I'm sorry, more restrictive on a seven-day average. Sorry. Less restrictive on a seven-day average.
Q. Why is a 14-day average used?
A. Okay. To answer this question, I think I need to go into a little bit background on some more of the process of the tides and how they influence flows in the interior Delta.
Q. Okay.
A. There's been testimony, we've talked about the semi-diurnal sloshing of the tide, the two flood tides, two ebb tides each day. So that's one component of the tides and how it affects the interior channels in the Delta. And the result is a net either negative flow or net positive flow.
There is also an effect of the moon on the tides and on these flows in these interior channels. And so this is superimposed on the daily sloshing. There is approximately a seven-day filling of the Delta on a net flow basis and a seven-day draining of the Delta on a seven-day basis. So a cycle from -- and the filling is referred to as the spring tide and the draining is the neap tide. So there is essentially a 14-day period between -- from spring tide to spring tide because the spring tides occur both during the full moon and the new moon.

Q. Are there any other --
A. Um --
Q. -- influences -- are there any other factors that support a 14-day running average?
A. Well, I -- that's -- this cycle has been recognized in the other standards that we're required to meet as part of the D 1641, as far as the salinity requirements that are within the interior of the Delta that is influenced by this neap/spring cycle. All of those standards are based on a 14-day running average. And the Old and Middle River objective, Old and Middle River at this -- as measured is also affected by this neap spring cycle.
Q. I believe in your declaration you also testified -- stated that there were certain meteorological events that make a 14-day running average an appropriate measurement.
A. Well, yeah, the -- in addition to the astronomical effects on the tides, which are predictable based on movement of the moon around the earth, there are other aspects of the tide that are -- that are not predictable and not very well understood. And these would be the effects, the meteorological effects on the tides. And this would be winds, barometric pressure, storm surges.
And these have effects on the short-term on the stages and flows of the channels within the Delta, on a short-term basis, that overwhelm this longer term process of



the tides as far as the spring and neap.
So it would be extremely challenging to meet a short duration objective or running average objective, just for practical purposes of the projects being able to adjust their operations in a way to compensate for these very large effects from meteorological influences.
Q. Are you familiar with the 2006 Water Quality Control Plan?
A. Yes.
Q. Are you familiar with the quantitative flow objectives for river flows and Delta outflows as discussed in the 2006 Water Quality Control Plan?
A. Yes.
Q. How are those quantitative flow objectives determined in the water quality control plan?
A. The -- well, the main flow objective that's in the water quality control plan would be net Delta outflow index. And that is an index. It is not a measured flow. It is a calculated flow based on -- it's an equation based on inputs and outputs into the Delta. The inputs would be the inflows primarily from the Sacramento River as measured at Freeport, the San Joaquin River as measured at Vernalis. The outputs would be consumptive use within the Delta and the project exports in the south Delta. So you've got the plusses of the inflows, the minuses of the consumptive use and the exports and that gives you a net Delta outflow.



Q. Are the Delta outflow objectives met based on an averaging period?
A. Yes.
Q. And what is that period?
A. Well, most of the Delta outflow objectives have either have a 30-day -- based on a monthly average, usually with a provision for seven-day -- seven-day minimum as well.
Q. Are there any outflow objectives that are met based on a three-day running average?
A. Yes. There is. One of the ways to meet one of the more complicated standards in the D 1641, which is the X2 standards for protection of delta smelt, one of the ways to meet that objective is through a three-day running average for Delta outflow.
Q. Under the Water Quality Control Plan, is there a salinity standard?
A. Yes. There are numerous salinity standards. Yes.
Q. And where is salinity measured under the water quality control plan?
A. Well, there's various -- various ones. There's -- in the interior of the Delta, primarily Jersey Point, Emmaton, there are other requirement -- M and I salinity requirements at other places.
Q. Does the water quality control plan provide an averaging period over which the projects maintain salinity levels?



A. Yes. Those locations in the interior Delta for agricultural salinity are based on 14-day running average.
Q. Is there a reason why, on that one instance, Delta outflows can be measured using a three-day running average or can be maintained, rather, using a three-day running average while salinity levels require a 14-day running average?
A. Yes. The components, as I stated, that go into calculating the Delta outflow. The inflow, the observed inflow is at Freeport on the Sacramento River, Vernalis on the San Joaquin River. These are essentially on the periphery of the Delta and they are not influenced by this neap/spring tide cycle.
Q. In your --
A. So we could -- we could meet it in a shorter duration.
Q. The one, the Delta outflow requirement that's based on a three-day running average.
A. Yes.
Q. That could be met on a three-day running average.
A. Yes. And that's only one way to meet that particular standard.
Q. But the salinity levels need to be maintained on a 14-day running average; correct?
A. That's correct.
Q. And is that because they are more tidally influenced?
A. Yes. Essentially that would be to filter out the effects

of this neap/spring tidal cycle.
Q. Are the flows in Old and Middle Rivers also tidally influenced?
A. Yes.
Q. In your opinion, would it be possible for the projects to meet the flow objectives outlined in the plaintiffs' proposed remedy based on a five-day running average?
A. It would be very challenging, as I stated earlier, because of -- more so because of the meteorological effects. The astronomical effects could be -- can be predicted to a certain extent. But the meteorological effects cannot. And so it would be quite challenging.
If we had to meet it with a five-day running average, we would have to operate very conservatively. We'd have to target Old and Middle River flow objectives much more less negative than the objectives from the proposal, thereby incurring greater water costs than have been analyzed in our table here.
Q. And would the same hold true for attempting to meet Old and Middle River flows based on -- as outlined in either the Fish & Wildlife Service remedy or in the Department of Water Resources modifications to the Fish & Wildlife Service's remedy on a five-day average?
A. Yes, it would be just as challenging.
THE COURT: Give me, in succinct terms, why that is.



What is it about the five-day running average that makes this more difficult?
THE WITNESS: Well, it is -- in the short duration, you can have these meteorological effects, like I said, the winds, the Delta -- the onshore winds, the barometric pressure, when barometric pressure is very low, you tend to see a big increase in stage in the interior Delta, which is caused by this -- by the flows coming in from the bay and they're causing -- they tend to make the flows much more negative. And they actually overwhelm the normal predictable cycle of the tides. And this will happen for a period of a day or two as you get a storm system coming through the Delta.
And so we can predict this ahead of time, what the effects of those are going to be. And with only five days, and we're looking at an average, it would be very challenging to -- we'd have to make, for example, if we got one of these storm surges, we'd have to make a significant change in our export operations that may not even be enough in order to meet that requirement, that five-day average.
THE COURT: There have been seven-day averages referred to as well as the 14-day averages.
THE WITNESS: Right.
THE COURT: And for this particular measure, is there a preference as to a running average that is to be met?
THE WITNESS: Well, the preference would be the



14-day average. There is a provision in there for an upper cap of seven days that is not as restrictive as the 14 days. So that's kind of in recognition of -- well, that essentially puts a cap so we couldn't vary too greatly within that 14 days on meeting whatever the particular objective is.
THE COURT: And is the reason that the 14 days is more feasible because that gives more time for whatever natural conditions are to operate which would then enable DWR or CVP not to take affirmative measures?
THE WITNESS: I'm not sure if I fully understood --
THE COURT: What I'm saying is, in the most simplistic terms, you've described what are, in effect, natural causes that affect the direction of flow in the Delta. And these relate to all the different things you've talked about. Tides. Meteorological conditions. I thought I heard astrological, but I --
THE WITNESS: I meant to say astronomical.
THE COURT: Astronomical. All right. I don't think we're using astrology yet in this case. Before it's over, we may get there.
Does the longer period in effect permit the natural courses to operate to meet the running average without either reducing exports, putting more water into the system to try to effect the direction of flows? Is that --
THE WITNESS: Well, yeah --



THE COURT: -- the practical result?
THE WITNESS: That would be the practical result. Tend to stabilize the operations to a --
THE COURT: To require less action by the operators.
THE WITNESS: Yes. And -- that's correct. And as I said, as that duration of time gets shorter and shorter, we would have to operate more and more conservatively to actually target objectives further below or more restrictive than what's in any of these proposals in order to ensure that we do meet the proposals' objectives.
THE COURT: And do you see any net benefit to this shorter period?
THE WITNESS: I don't.
THE COURT: Thank you. You may continue.
BY MS. WORDHAM:
Q. Mr. Leahigh, are there any other operations that draw water from the Delta besides the State Water Project and Central Valley Project that could have an influence on the flows in Old and Middle Rivers?
A. Yes. There are other diverters in the south Delta upstream of the measuring point for Old and Middle River flows. These would be agricultural diverters as well as M and I diverters. Contra Costa Water District, for example.
Q. And have you had occasion to quantify the amount of their diversions?

A. Well, it varies throughout the year. But at their peak, it's estimated that the agricultural diverters upstream of the Old and Middle River sites could be in the order of 1,000, 1500 during the peak of their water -- their demand for agricultural uses. Contra Costa Water District probably -- and this is at their Old River pumping plant, is probably on the order of about 200 cfs or so.
Q. You're familiar with DWR's revised remedy proposal; is that correct?
A. That's correct.
Q. Under DWR's remedy actions three and four -- well, three, do you know what the flow requirements are?
A. The flow objective for Old and Middle River varies from 1500 -- negative 1500 cfs to negative 4,000.
Q. Is that different from the Fish & Wildlife Service's flow objectives for action three?
A. Yes. The Fish & Wildlife Service's is from zero or non-negative flow to negative 4,000 cfs.
Q. In your opinion, could the agricultural diversions and the -- and the M and I, or municipal and industrial diversions that you were just describing, have an effect on the project's ability to meet a zero or non-negative flow requirement in Old and Middle Rivers during the time period of action three?
A. Yes. In -- during the time period of action three, which is late spring, that's right at the time when the agricultural



users are starting to peak their diversions out of the Delta. If that's in combination with a low flow on the San Joaquin River, also if there were -- happened to be in the part of the spring/neap tidal cycle that is the spring, which tends the tendency to cause more negative flows on the interior Delta, it's possible we could see negative flows without any pumping at all at either facility. At either project, project export facility.
Q. So in your opinion, if the projects were required to operate to the slightly less restrictive requirements of DWR's proposal of negative 1500 cfs, would they be able -- would it be possible for them to -- let me rephrase.
Would it be easier for them to meet those flow objectives given the agricultural diversions and municipal and industrial diversions that you've described?
A. Yes. It would be much more practical to be able to meet that level of flow given all the other factors that are outside of our control.
MS. WORDHAM: One moment, Your Honor.
THE COURT: Yes.
MS. WORDHAM: Thank you, Your Honor. I have no further questions at this time.
THE COURT: Thank you very much. Do the plaintiffs wish to cross-examine?
MS. JAISWAL: Yes, Your Honor.



THE COURT: All right. You may proceed.
CROSS-EXAMINATION
BY MS. JAISWAL:
Q. Good morning, Your Honor. Good morning, Mr. Leahigh. I'm Anjali Jaiswal representing the plaintiffs. Before I begin the cross-examination, I just wanted to restate our continuing objection, Your Honor.
THE COURT: Yes. You may proceed.
BY MS. JAISWAL:
Q. Mr. Leahigh --
THE COURT: It is noted.
BY MS. JAISWAL:
Q. Mr. Leahigh, I am going to begin with the Department of Water Resources Exhibit N. Do you have that in front of you?
A. Yes.
Q. You've already read the title of this exhibit. And you've already testified that actions one through three propose monitoring; correct?
A. Correct.
Q. And that's for both the plaintiffs, the original as well as the revised; correct?
A. That's correct.
Q. And the charts for actions one, two, three -- excuse me. The chart states that for actions one through three, there will be no cost; is that correct?



A. Correct.
Q. Now, let's go to your Exhibit C, which has been marked -- let's see. That is contained in Department of Water Resources Exhibit J and it has also been separately entered, I believe, as Exhibit K. Do you have that in front of you?
A. Yes, I do.
Q. Thank you.
MS. WORDHAM: Your Honor, I'm having a hard time hearing counsel. I apologize, but I am having a hard time hearing counsel.
THE COURT: If you could try to speak directly into the microphone.
MS. JAISWAL: I will do my best, Your Honor.
THE COURT: Thank you. Yes, you have a soft voice.
BY MS. JAISWAL:
Q. Looking at Exhibit C attached to your supplemental declaration -- is that better?
MS. WORDHAM: Thank you.
MS. JAISWAL: Okay. I will hold it the best that I can.
Q. If I could direct your attention to the chart on the right. That is the service's action matrix; correct?
A. Correct.
Q. And there are -- there is no equivalent to actions one, two, three; correct?

A. Correct.
Q. Now if I could go back to Exhibit N. Department of Water Resources Exhibit N. When you look at both charts for plaintiffs' action 6, that's VAMP; correct?
A. Correct.
Q. And for both of those across the board, there's no cost; correct?
A. That's correct.
Q. And just moving down quickly to eight and nine, again, the barriers. And for both of those across the board, there's no cost; correct?
A. Correct.
Q. Thank you. So in analyzing, you concluded that six of ten of the plaintiffs' actions had no cost; correct?
A. That's correct.
Q. Thank you. Moving on. Your analysis evaluated the remedy proposals only under a dry and average year hydrological condition; correct?
A. Correct.
Q. Mr. Leahigh, do you have in front of you your supplemental exhibit, which has been introduced as -- which has been entered as Department of Water Resources Exhibit I?
A. Yes. I have it.
Q. Take a look at Exhibit A. This exhibit indicates that there are five classifications for hydrological year types;



correct?
A. I'm sorry. Is this -- this would be my supplemental declaration?
Q. Yes.
A. I think that's DWR --
Q. I'm sorry. That is J.
A. J. Okay. Yes, I have that and I'm looking at Exhibit A to that supplemental declaration.
Q. Great. And -- is that better? Everyone can hear me better now? Great. Thank you for turning up the microphone.
So when you look at Exhibit A, you see five classifications for hydrological year types; correct?
A. That's correct.
Q. And in your analysis of the various proposals, you did not present any analysis for wet years; is that correct?
A. That's correct. The 50 percent exceedance, I believe, falls under above normal category.
Q. Thank you. And so if 2008 were a wet year, the water cost of plaintiffs' proposal would be less; correct?
A. It would depend.
Q. You testified that for conditions above normal, the projects could meet their contractor demands.
MS. WORDHAM: Objection. Misstates his testimony.
MS. JAISWAL: Could you please explain what you testified -- I'm sorry, Your Honor.



THE COURT: Let me rule on the objection. The objection is sustained. You may rephrase.
MS. JAISWAL: Thank you.
Q. Mr. Leahigh, would you please restate what you informed the Court today regarding wet year analysis.
MS. WORDHAM: Objection. Vague.
THE COURT: Do you understand the question?
THE WITNESS: I believe -- I believe I do.
THE COURT: Overruled. You may answer.
THE WITNESS: I think you're referring to a comment I made that doing an analysis on years wetter than the 50 percent exceedance, I believe I stated that we typically do not look at year types that are wetter because we're able to meet most of the delivery requests of our contractors. That -- I think that's what I stated earlier.
The question about wetter years, and I -- the reason I answered "It depends" is because it's possible, it depends on which basin receives more water. If, for example, Sacramento were wet, San Joaquin were drier, the cost could actually be greater than what was analyzed in our assessment.
If you've got a wet San Joaquin basin and a drier San Joaquin, then yes, those costs would tend to come down. On the most extreme wet years, it's possible that the cost could be zero for -- at least for the spring actions. There's the -- yeah, that's -- that would be my analysis of wet year



and the effect of a wet year on these proposals.
BY MS. JAISWAL:
Q. Thank you, Mr. Leahigh.
You testified that you reviewed Mr. Rosekrans' evaluation; correct?
A. Yes.
Q. His declaration.
A. Yes.
Q. Do you have Plaintiffs' Exhibit 25 in front of you?
A. I'm sorry. Which exhibit?
THE COURT: 25. I don't think he has it up there.
MS. JAISWAL: Your Honor, yesterday I gave the witness' copies to the Court --
THE CLERK: I put them over there.
THE COURT: If you can look, it should have a pink tag on it with 25.
THE WITNESS: I found it.
THE COURT: All right.
BY MS. JAISWAL:
Q. Mr. Leahigh, would you please turn to the last page of Mr. Rosekrans' exhibit.
A. Exhibit, the SR Supplemental 2?
Q. Yes. Thank you.
MS. JAISWAL: Your Honor, for ease of the Court, I would like to identify this separately as Plaintiffs' Exhibit

26.

THE COURT: All right. Any objection? 26 for identification.

(Plaintiffs' Exhibit 26 was marked for identification.)

BY MS. JAISWAL:

Q. Mr. Leahigh, looking at plaintiffs' 26, Mr. Rosekrans analyzed impacts over a range of hydrological year types; is that correct?

THE CLERK: Excuse me. Did you give me two copies of the same thing? One for the witness or --

MS. POOLE: I gave you two copies.

THE CLERK: Okay.

THE WITNESS: I'm sorry. Could you repeat the question?

MS. JAISWAL: Yes. Should I have the court reporter repeat it?

THE COURT: Can you read it back?

(Record read as requested.)

THE WITNESS: Not necessary -- no. I think what Mr. Rosekrans did was look at a number -- look at historical data from a number of years in the past that fell under different year types.

BY MS. JAISWAL:

Q. And those year types are critical to wet; correct? If you



look at the exhibit, there's critical, critical dry, below normal, above normal, normal wet. Those are the five year types?

A. The years that were analyzed, yeah, they fall under critical to wet with the exception of a "below normal." I don't see a "below normal."

Q. Thank you. There's -- if I could draw your attention to 2003.

A. Okay. On the San Joaquin Valley, you're correct, that was below normal.

Q. So the exhibit also shows that Mr. Rosekrans included beginning of year storage for purpose of this analysis; correct?

A. In his analysis, he states what the beginning of year storages were for each of those years, yes.

Q. Thank you. And Mr. Rosekrans determined that exports would be reduced on average by 1.652 million acre feet for plaintiffs' interim protections; correct?

A. He -- okay. I see that. He shows that as the average of all of those years that he analyzed. Yes.

Q. Thank you. And Mr. Rosekrans determined that exports would be reduced by 923,000 acre feet for a wet -- for wet year conditions; is that correct?

A. Well, for that particular year, 1995, under the conditions that existed in that particular year, that's what he came up



with.

Q. And 1995 was a wet year; correct?

A. 1995 was a wet year.

Q. Moving on, Mr. Leahigh. Do you have in front of you your exhibit, your supplemental exhibit, and that, again, is Defendants' J. Department of Water Resources J.

THE COURT: Before you move on, let me ask Mr. Leahigh two questions. Go back, if you would, to Exhibit 26. Look at the total storage. Do you agree that that is the total storage? Is this for both projects?

THE WITNESS: It looks as if it is for both projects.

THE COURT: And the historic exports, is that -- it's 5,201,000. Does that comport with your recollection? These are selected years obviously.

THE WITNESS: Right. You know, I have no way of verifying that right here, but I'll assume it's correct.

THE COURT: All right. Thank you. You may proceed.

THE WITNESS: And --

MS. JAISWAL: Thank you, Your Honor.

Q. Mr. Leahigh, if I could direct you to your Exhibit J, which has also been marked as Exhibit K, which is Exhibit C to your supplemental declaration.

A. Yes, I have it.

Q. Please let me direct your attention to the right box.

A. Okay.



Q. If you could go to the service's action item four.

A. Okay.

Q. Okay. For action item four, you assumed two assumptions; correct?

A. Yes.

Q. And you assumed Old and Middle River flows greater than zero and Old and Middle River flows greater than negative 4,000. I'm sorry. Greater than negative 4,000. Correct?

A. That's correct.

Q. Now, if you could please find federal Defendants' Exhibit A, I believe, that is a declaration of Ms. Goude.

THE COURT: Before you do that, let me ask about this second figure. Is it your understanding that the June 1st to June 30th period, this follows the Vernalis Adaptive Management Period, the flows are supposed to be maintained greater than zero and greater -- or should that be less than minus 4,000? Isn't that a bracket between zero and minus 4,000?

THE WITNESS: It is a bracket between zero and negative 4,000.

THE COURT: It should be a less than rather a greater than sign?

THE WITNESS: No, the objective should be to maintain a flow less negative than negative 4,000. So it should be greater than negative 4,000. I think that's stated correctly.

1 THE COURT: Thank you.
2 MS. JAISWAL: May I continue, Your Honor?
3 THE COURT: Yes.
4 MS. JAISWAL: Thank you.
5 Q. Mr. Leahigh, if I could please direct your attention to
6 Federal Defendants' A. That's the declaration of Ms. Goude
7 that's docket number 396-5.
8 MR. MAYSONETT: Your Honor, I believe it's actually
9 Federal Defendants' 3.
10 MS. JAISWAL: Thank you.
11 THE COURT: Do you have it?
12 THE WITNESS: Exhibit 3? These appear to be letters
13 here.
14 THE COURT: The declaration of Ms. Goude.
15 MS. JAISWAL: I can separately introduce it.
16 THE COURT: Have you found it?
17 THE WITNESS: Thank you. I have it.
18 MS. JAISWAL: Thank you very much for finding it.
19 Q. Now, if you could please turn to what is Exhibit 2 and it
20 is on page 8 of 24 on the top following the docket numbers.
21 A. Yes, I have it.
22 Q. If you could go down to action number four. This is the
23 service's action number four that's attached to Ms. Goude's
24 declaration. Please review action number four.
25 A. Okay.



1 Q. Nothing in the service's action matrix for action four
2 requires the flows that you used in your analysis as described
3 in your Exhibit C; is that correct?
4 A. Well, it doesn't explicitly state it on this particular
5 document, but I believe it's referenced in the footnotes to
6 this table.
7 Q. If you could go to the footnotes of the table.
8 A. It would be the next page.
9 Q. Please read the footnote to yourself.
10 A. Okay.
11 Q. Does anything in the footnote for action four specify the
12 assumptions that you used in your analysis for action four?
13 A. Well, footnote six, although footnote six is not
14 referenced for action --
15 Q. Thank you. For action four.
16 A. I believe that was the intent.
17 Q. But nothing in the footnote and nothing in the action
18 matrix explicitly states the assumptions that you explicitly
19 used in your exhibit and model; is that correct?
20 A. Well, I don't see it right now.
21 Q. Thank you.
22 A. But --
23 Q. The service's action four is actually a process. It's not
24 a flow standard; correct?
25 A. It is a process. With actions three and four, the



1 objective can vary.
2 Q. Thank you.
3 A. But the process is the same.
4 Q. And it's a process that's not dissimilar to DSRAM, the
5 Delta Smelt Risk Assessment Matrix; correct?
6 MS. WORDHAM: Objection. Exceeds the scope of this
7 witness' direct.
8 THE COURT: The subject is action four and I will
9 permit a comparison to be made. Objection's overruled. That
10 subject was covered on direct. Although not the DSRAM. You
11 may answer.
12 MR. WILKINSON: Your Honor, I'm also going to object
13 on the grounds of vagueness.
14 THE COURT: All right. Do you understand the
15 question?
16 THE WITNESS: I think it is somewhat vague.
17 THE COURT: Sustained. Rephrase, please.
18 BY MS. JAISWAL:
19 Q. Are you familiar with the Delta Smelt Risk Assessment
20 Matrix, Mr. Leahigh?
21 A. Yes.
22 Q. The delta smelt risk assessment matrix set up a process;
23 didn't it?
24 MS. WORDHAM: Objection. Vague as to "process."
25 THE COURT: Do you understand the question?



1 THE WITNESS: Sort of.
2 THE COURT: Well, you don't have to define your
3 question. I'll sustain the objection. You may rephrase.
4 BY MS. JAISWAL:
5 Q. Could you please explain how DSRAM differs from the
6 service's action four?
7 A. I think we're comparing apples and oranges. I don't think
8 there is any comparison.
9 Q. Thank you, Mr. Leahigh. Moving on.
10 Your Honor, did the Court have anything further?
11 THE COURT: No, I don't.
12 BY MS. JAISWAL:
13 Q. Mr. Leahigh, you analyzed the water costs for plaintiffs'
14 interim protective action seven; correct?
15 A. Yes.
16 Q. And in analyzing plaintiffs' action seven, you selected an
17 end date of July 15th as the end of juvenile salvage; correct?
18 A. Yes.
19 Q. Earlier in your testimony, did you testify to the effect
20 that relying on historical data is not useful?
21 MS. WORDHAM: Objection. Misstates his testimony.
22 THE COURT: Well, it seems to be an incomplete
23 question. Are you able to answer the question in its present
24 form? If you don't agree with it, you can simply say --
25 THE WITNESS: It's not clear enough.

THE COURT: All right. Sustained. You may rephrase.
MS. JAISWAL: Thank you.
Q. Mr. Leahigh, this morning, did you testify and use as a criticism using historical data and using historical data is not useful? Do you recall testifying to something to that effect?
MS. WORDHAM: Objection. Vague.
THE COURT: Well, do you understand the question?
THE WITNESS: Yes. Yes.
THE COURT: If you don't, say so.
THE WITNESS: Yes.
THE COURT: All right. Overruled. You may answer.
THE WITNESS: I criticized the use of historical data when the parameter that you're looking at is known. So if you -- for example, if you know what carryover storage is going into next year, then you should use it. You shouldn't rely on historical data for that particular parameter.
BY MS. JAISWAL:
Q. Thank you. And for action seven, you relied on historical data; is that correct?
A. Yes. Because it's not known when the last salvage of data will be detected at the facilities. So this is not a known quantity. So that's the only estimate that we could have, that would be the best estimate available to us.
Q. You also testified earlier today -- and I'm probably not



going to get the testimony exactly right, so maybe you could help me out and restate what you said. But you testified something to the effect that selecting July 15th as your end date is a critical assumption. Is that correct?
A. Yes.
Q. And you testified, and please correct me if I misstate it unintentionally, because this time period of 6-15 to 7-15 is a peak demand time period. Is that correct?
A. That's correct.
Q. Are you aware that plaintiffs' proposal specifies an end date of June 15th or five days after the end of salvage?
A. Yes.
Q. Mr. Leahigh, you were here last week during Ms. Goude's testimony; weren't you?
A. For the first half of her testimony on Thursday, but not on Friday.
Q. Do you recall Ms. Goude evaluating the years for the end of juvenile salvage?
A. No.
Q. Okay. Sounds like you weren't here.
If I could direct your attention to your supplemental exhibit. I'm sorry. Your supplemental declaration. And that, for the record, has been identified as Exhibit J for the Department of Water Resources.
A. I have it.



Q. Okay. Please go to -- you've looked at this chart earlier today; haven't you?
A. Which chart? I'm sorry.
Q. It's Exhibit D -- I'm sorry. If you could go to your Exhibit D in that exhibit.
A. Yes. I am familiar with it.
Q. Thank you. Can you please look at 2006.
A. Yes.
Q. When does salvage end in 2006?
A. The last day of salvage is listed as April 22nd at the state facility.
Q. Thank you. In such years, plaintiffs' action seven would end on June 15th; correct?
MS. WORDHAM: Objection. Vague as to "such years."
MS. JAISWAL: In years --
THE COURT: Sustained.
MS. JAISWAL: I'm sorry.
Q. In years like 2006, plaintiffs' action seven would end on June 15th; correct?
A. Yes.
Q. In your analysis, you did not present the calculation of water costs in plaintiffs' action seven ended on June 15th; did you?
A. No, I don't believe so.
Q. Thank you. How about June 30th?



A. No.
Q. Thank you. Now, Mr. Leahigh, if you could please go to Plaintiffs' Exhibit 4, I believe, that is Dr. Swanson's supplemental declaration.
A. Okay. I have it.
Q. I believe you were referring to it earlier today.
A. Probably. I have it.
Q. Thank you. If you could please turn to page 32. And I'm going to read from line two starting with "Under the much lower reverse flow."
And if you could tell me if I'm accurate.
"Under the much lower reverse flow conditions for Old and Middle River specified in plaintiffs' action seven and the preceding months (i.e., plaintiffs' actions five and six) it is likely that the movement of young delta smelt from the Delta channels and sloughs where they were hatched to downstream rearing areas near the confluence and in Suisun Bay and beyond the influence of export pumps would have been improved and few or no fish would remain in the south Delta as late as July."
A. That's what it says.
Q. Thank you. And that's Dr. Swanson's declaration; correct?
A. That's correct.
Q. So is it fair to say that plaintiffs' action seven could end as early as June 15th?

1 MR. WILKINSON: Your Honor, I'm going to object on
2 the basis that this calls for an answer that's beyond the
3 scope of the witness' expertise.
4 THE COURT: It appears to be asking him what the
5 exhibit says. Isn't the proposal for it to end on June 15th?
6 MS. JAISWAL: Yes, Your Honor.
7 MR. WILKINSON: If counsel is asking for his
8 interpretation of when the last smelt would be taken, I
9 believe that gets into biological expertise.
10 THE COURT: The question could be asked directly.
11 I'm going to sustain the objection to the form of the
12 question. You may rephrase it.
13 MS. JAISWAL: Your Honor, he offered his opinion
14 exactly on that during direct.
15 THE COURT: Yes. No question about it. But are you
16 asking him is it possible that the last salvage could be -- of
17 juvenile could be taken on June 15th? Is that your question?
18 MS. JAISWAL: Yes, Your Honor.
19 THE COURT: Answer that question.
20 MR. WILKINSON: Goes beyond his expertise.
21 THE COURT: What?
22 MR. WILKINSON: I believe that goes beyond his
23 expertise, Your Honor.
24 THE COURT: Well, here he's being asked to interpret
25 and he covered it in direct. In fact, I think he expressed



1 his opinion that the last date of salvage would be July 15th.
2 And that he chose.
3 MR. WILKINSON: Well, my recollection was that he
4 read from certain data about smelt collections.
5 THE COURT: Let's ask him. Do you have that opinion
6 that the most efficacious date for the last salvage of
7 juvenile delta smelt is July the 15th? Do you personally hold
8 that opinion or are you just --
9 THE WITNESS: Well, the historical data shows an
10 example of where actions that were even more protective at Old
11 and Middle River resulted in fish salvage into July.
12 THE COURT: So as the project leader, then you
13 endorse July 15th as the last date of salvage for juveniles?
14 THE WITNESS: Yes. I believe that would be the more
15 prudent way to assess potential water costs.
16 THE COURT: All right. Now you're being asked what
17 about July 15th, is that a reasonable date for last salvage of
18 juveniles?
19 THE WITNESS: June 15th?
20 THE COURT: June 15th. I'm sorry.
21 THE WITNESS: If I were to be shown evidence that
22 supported some historical data that showed Old and Middle
23 River flows similar to the plaintiffs' actions five and six
24 taking place and also salvage, the last salvage occurring
25 before June 15th, I could say yes. But I don't see that date.



1 THE COURT: You don't have any basis for that now?
2 THE WITNESS: I don't see that date in front of me.
3 THE COURT: So you don't have that opinion?
4 THE WITNESS: I don't have that opinion.
5 MS. JAISWAL: Thank you, Your Honor.
6 Q. If you assumed that what Dr. Swanson said in her
7 declaration, which I read, is correct.
8 A. Would I assume that?
9 Q. If you would, please --
10 THE COURT: You're being asked.
11 THE WITNESS: Oh, I see. Okay. I will assume that.
12 BY MS. JAISWAL:
13 Q. Thank you. Would plaintiffs' action -- could plaintiffs'
14 action seven end as early as June 15th?
15 A. If I assume what she's saying is correct?
16 Q. Yes.
17 A. Then --
18 Q. Could it end as early as June 15th?
19 A. I suppose so.
20 Q. Thank you. If I could direct your attention back to your
21 supplemental declaration and your Exhibit C to your
22 supplemental declaration, which is in evidence as Exhibit J as
23 well as Exhibit K.
24 A. Okay.
25 Q. Your analysis goes for a two -month period; correct?



1 THE COURT: Analysis of what?
2 BY MS. JAISWAL:
3 Q. I'm sorry. Your analysis for action seven goes for a
4 two-month period, from May 16th to July 15th; correct?
5 A. That's correct. That's the assumption.
6 Q. Thank you. The assumption. If you choose the June 15th
7 as an end date, it cuts the duration of action seven in half;
8 correct?
9 A. Yes. That would cut the assumption in half.
10 Q. It goes from a two-month period to a single month period;
11 correct?
12 A. Correct.
13 Q. If you assume an end date of June 15th, which you've
14 already done once, and all other factors remain the same, in
15 your water cost modeling, plaintiffs' action seven would have
16 significant -- excuse me, would have significantly less water
17 cost for an average year; correct?
18 MS. WORDHAM: Objection. Vague as to
19 "significantly."
20 MS. JAISWAL: I'm asking --
21 THE COURT: All right. Do you understand what is
22 meant by the term "significantly"?
23 THE WITNESS: Not exactly, no.
24 THE COURT: Sustained. You may rephrase.
25 BY MS. JAISWAL:

Q. Would it be reduced by a quarter? Could it be reduced by a quarter?
A. The cost of just that action?
Q. Yes.
A. Probably. I don't have -- yeah, probably.
Q. Could it be reduced by half?
A. I don't know for sure, but it's possible.
Q. Thank you. Moving on.
Are you aware that in California water districts sell and exchange water amongst themselves?
MS. WORDHAM: Objection. Exceeds the scope of his direct.
THE COURT: Yes, it does. The objection is sustained.
BY MS. JAISWAL:
Q. I believe on direct you were asked about water districts and exchange of water among water districts.
MS. WORDHAM: Objection. Misstates his testimony. Misstates the direct examination.
THE COURT: Well, he was asked a question. I know because I asked it.
MS. WORDHAM: Fair enough, Your Honor.
THE COURT: So I guess you were asked such a question. Do you agree?
THE WITNESS: I guess I was.



THE COURT: You can contradict me.
THE WITNESS: I don't remember it, but if you say I did, I suppose I did.
MS. JAISWAL: Thank you.
Q. You did not adjust your delivery reduction estimates to reflect that water users can purchase additional supplies from other users; correct?
A. Did I -- did I testify to that? Is that what you're asking?
Q. No. I'm just asking you the simple -- I tried to format my question so that they would be yes or no type questions. So it would be great if we could follow that format. But if you don't understand, please let me know and I will clarify.
A. Okay. I'm sorry. Could you repeat the question?
MS. JAISWAL: Should I have the reporter repeat it.
THE COURT: Yes, you may. Can you read back the question, please?
(Record read as requested.)
THE WITNESS: No, because that wouldn't be relevant to my analysis as far as State Water Project's delivery capabilities.
BY MS. JAISWAL:
Q. So the answer is no; correct?
A. The answer is no.
Q. Thank you. You are aware of the Environmental Water



Account; correct?
A. Yes.
Q. Are you aware that water from the Environmental Water Account may be made available to compensate for export reductions to meet environmental requirements?
A. Yes, I testified as such.
Q. Now I'm going into the territory where I'm trying to get your testimony from earlier today. And I don't have an instantaneous transcript unfortunately. So if I don't get this right, please help me along and clarify what you testified to.
But you testified that there is somewhere -- 300,000 acre feet for the Environmental Water Account?
A. Typically that's a range of assets that would be available.
Q. Now, if I could draw your attention back to your Exhibit C attached to your supplemental declaration, which is in -- which is in evidence as J as well as K.
A. Yes.
Q. Actually, I'm sorry, if you could go to N, the new one.
A. Okay. I have it.
Q. Thank you. Now, when you look to plaintiffs' revised proposal and you look at the cost for some of these actions, some of the actions are less than 300,000 acre feet; aren't they?



A. The plaintiffs' proposals?
Q. In your analysis of the plaintiffs' revised proposal. It is the right-hand chart. Right-hand side of the chart. And if you look at the export reductions.
A. I'm looking at DWR Exhibit N, which is --
Q. I'm sorry. Exhibit M like Mary.
A. Oh, I'm sorry.
THE COURT: Oh.
THE WITNESS: Okay. I have it.
BY MS. JAISWAL:
Q. Thank you. Now for Exhibit M, if you look at the right-hand chart, which is the plaintiffs' revised proposal August 13th.
A. Yes.
Q. And when you look at the export reductions there, some of those reductions are less than 300,000 acre feet; is that correct?
A. Yes. Some of the individual actions or portions of actions are less than 300,000 acre feet.
Q. And for action ten, for a dry year, it's 350,000 acre feet; is that correct?
A. That is just the export reduction part of meeting that action. There's an additional 310,000 acre feet above stream required.
Q. Thank you. My question was to action ten.

A. Yes. And that's the one I'm referring to.
Q. Thank you. A final question on the Environmental Water Account. You didn't adjust your model -- your model delivery estimates to reflect the water that may be available to compensate for reductions from the Environmental Water Account; did you?
MS. WORDHAM: Objection. Asked and answered.
THE COURT: I'm not sure it was answered. Did you make any such adjustments? Did you assume Environmental Water Account availability?
THE WITNESS: No. I think I did state that earlier, that that was not applied to these costs, Environmental Water Account mitigation for these costs was not.
BY MS. JAISWAL:
Q. Thank you. I'm moving on now. Many customers of the State Water Project and Central Valley Project use non-project sources of water; right?
MR. WILKINSON: Objection.
MS. WORDHAM: Objection. Exceeds the scope of the direct.
MR. WILKINSON: We concur. Join in the objection.
THE COURT: Yes. The objection is sustained. It does exceed the scope of direct. You may ask your next question.
BY MS. JAISWAL:



Q. Mr. Leahigh, in your supplemental declaration, you stated that implementation of plaintiffs' action ten could be achieved by either export reductions or upstream storage releases or a combination; correct?
A. Yes. But there would be impacts associated with both upstream and --
Q. My question is what you stated in your supplemental declaration. And the question is: You stated in that declaration that implementation of plaintiffs' action ten could be achieved by either export reductions or upstream storage releases or a combination. Is that correct?
A. That's correct with a qualifier.
THE COURT: Yes. What is it?
THE WITNESS: The qualifier is that it could only be met with other impacts experienced elsewhere in system.
BY MS. JAISWAL:
Q. In your analysis, you choose to evaluate -- you chose to evaluate plaintiffs' action ten through a combination of storage and export reductions; is that correct?
A. Yes.
Q. Thank you. Increases in the San Joaquin River inflow could be used to help meet plaintiffs' action ten; is that correct?
A. Increases at San Joaquin River flow have a positive effect on Old and Middle River flow, yes.



Q. Thank you. In your water cost estimates, you assume that there would be releases from Oroville, Shasta and Folsom Reservoirs to meet plaintiffs' action ten; is that correct?
A. Yes.
Q. Thank you. Plaintiffs' recommended action ten doesn't specify a single reservoir; does it? Release from a single reservoir; does it?
A. No, it doesn't specify.
Q. And it doesn't require action ten solely based on releases from Oroville; does it?
A. No.
Q. In your water cost estimates, did you assume releases from New Melones Reservoir for plaintiffs' action ten?
A. No.
Q. Do you know what the current storage in New Melones reservoir is?
A. No, I don't.
MS. JAISWAL: Your Honor, if I could identify Plaintiffs' Exhibit 27. Let the record reflect that counsel has it before them. And if I may approach the witness, Your Honor.
THE COURT: Yes, you may.
(Plaintiffs' Exhibit 27 was marked for identification.)
BY MS. JAISWAL:



Q. Do you know what this document is?
A. This looks to be a printout from CDEC, California Data Exchange Center.
Q. Do you go on this website?
A. Yes, I do.
Q. Thank you. What is this exhibit?
A. Well, this looks to be data for New Melones Reservoir. And it looks to be -- it's a daily data. And this is data that goes through August 28th, 2007.
Q. Thank you. So for -- so looking at the chart, the storage level for New Melones, as of August 28th, is approximately 1.5 million acre feet; is that correct?
A. That's what this shows.
Q. Thank you.
MS. JAISWAL: Your Honor, if I may move to have Plaintiffs' Exhibit 27 admitted.
THE COURT: Any objection?
MR. WILKINSON: No objection.
THE COURT: Exhibit 27 is received in evidence.
(Plaintiffs' Exhibit 27 was received.)
THE COURT: What is your time estimate, Ms. Jaiswal?
MS. JAISWAL: Half an hour, Your Honor.
THE COURT: You may proceed.
MS. JAISWAL: Thank you. If I could identify Plaintiffs' Exhibit 28. Counsel has received a copy.

(Plaintiffs' Exhibit 28 was marked for identification.)
MS. JAISWAL: May I approach, Your Honor?
THE COURT: You may.
BY MS. JAISWAL:
Q. Mr. Leahigh, do you know what this document is?
A. I'm not familiar with this particular report, but --
Q. Have you seen this kind of report before?
A. Similar, yes.
Q. And what is the title of this?
A. Daily reservoir storage summary.
Q. Thank you. And where does it appear from? To be?
A. It looks like it is -- it could be a CDEC report.
Q. Thank you.
A. Same database.
Q. And where is it from?
A. Excuse me?
Q. Which agency is it from?
A. If it is CDEC, that would be Department of Water Resources.
Q. Right. At the top, that top bar reads "California Department of Water Resources"; is that correct? At the very top of the exhibit.
A. Very top of the exhibit actually I don't see that, but --
Q. There is a black bar at the top of page one.



A. Is it on the right-hand corner?
Q. It is on the left-hand corner.
MS. WORDHAM: Your Honor, counsel's copy does not have a black bar at the top across the top of page one.
THE COURT: Nor does mine.
MS. JAISWAL: I'm sorry, Your Honor, it seems that the correct copies were not photocopied. I have one copy of the exhibit that I would like to use.
THE COURT: You'll have to show it to other counsel. You can use the Elmo, Ms. Jaiswal.
MS. JAISWAL: Okay. Thank you for the excellent suggestion, Your Honor.
THE COURT: That means --
MS. JAISWAL: If I may show it to the rest of counsel, to make sure --
THE COURT: You may show it to counsel.
MS. JAISWAL: If I may put the exhibit on the Elmo?
THE COURT: You have to move it into evidence first.
MS. JAISWAL: Thank you, Your Honor.
THE COURT: Did you show it to the witness?
MS. JAISWAL: I have identified it as Plaintiffs' Exhibit 29, Your Honor. And if I may approach the witness.
THE COURT: It's Exhibit 29. All right. So 28 is withdrawn?
MS. JAISWAL: Yes, Your Honor.



THE COURT: All right.
(Plaintiffs' Exhibit 29 was marked for identification.)
THE COURT: Does the witness recognize the exhibit?
THE WITNESS: Yes. Now it's clear to me that this is from the California Data Exchange Center database.
THE COURT: All right.
MS. JAISWAL: Just so that the record is clear and Mr. Leahigh is clear, I have withdrawn Exhibit 28 and I am not relying on it and I apologize for the error in the copies.
Q. Now, if I could put Exhibit 29, Plaintiffs' Exhibit 29 on the Elmo.
THE COURT: The witness identifies it. Are you moving it into evidence?
MS. JAISWAL: I was going to ask a few questions and then move it into evidence, Your Honor. But I could do it at this time.
THE COURT: Any objection?
MR. WILKINSON: No objection.
MS. WORDHAM: None, Your Honor.
THE COURT: Exhibit 29 is received in evidence.
MS. JAISWAL: Thank you, Your Honor.
(Defendants' Exhibit 29 was received.)
BY MS. JAISWAL:
Q. Mr. Leahigh, can you read that? Overall, can you see it?



A. Yes, I can.
Q. And can you please read the black bar on the top of that exhibit?
A. It says California Department of Water Resources, Division of Flood Management.
Q. And what is that document?
A. This is a report from the California Data Exchange Center database.
Q. Thank you. Now I'm going to put up page two. It's a continuation from page one.
Now, this chart is a daily reservoir storage summary; correct?
A. That is the title of the report, yes.
Q. And now looking on page two, you can see on the Elmo where it says "2 of 2" on the corner; correct?
A. Correct.
Q. And the first one listed is New Melones Reservoir; is that correct?
A. Yes.
Q. And if you look at New Melones, you see that New Melones storage is currently at 108 percent of historical average; is that correct?
MS. WORDHAM: Your Honor, I would like to request that at least we can see the captions for each of the columns. As it's presently displayed on the Elmo, we cannot tell what

column she's referring to.
THE COURT: All right. Thank you. All right. Well, the exhibit does speak for itself. You may ask your next question.
MS. JAISWAL: Thank you.
Q. Now, if you could move to Don Pedro Reservoir. Have you located Don Pedro Reservoir? It's up on the Elmo.
A. Yes, I see it.
Q. And Don Pedro Reservoir is currently at 91 percent historical average; is that correct?
A. As of the date of this report, it shows it as 91 percent of average, yes.
Q. Thank you.
THE COURT: We've actually gone five minutes over our time period. We've got to give the reporter a break. I'm exceedingly concerned. We are not going to have enough time to finish this proceeding. What are we going to do?
MS. JAISWAL: After the break, Your Honor, if I could have 15 minutes and I will wrap up the cross-examination.
THE COURT: That is going to further cut into our time. We were hoping to get to arguments this morning, quite frankly.
What we're going to do is this. We're going to take a recess now. We're going to return at 1:30 and I want counsel to consider what is in the best interest of all



parties insofar as proceeding. What kind of questions are any of the other intervenors or the United States going to have for this witness.
MR. MAYSONETT: Your Honor, the federal defendants will have only very brief questioning for this witness.
MR. WILKINSON: That would be true for us, Your Honor, I would imagine it would be less than ten minutes.
MR. O'HANLON: I agree as well, Your Honor. If not five minutes.
THE COURT: Let's stand in recess until 1:30.
(Recess.)
THE COURT: All right. We're going back on the record in NRDC versus Kempthorne. We're going to complete the testimony of Mr. Leahigh. With dispatch, please.
MS. JAISWAL: Your Honor, I only have two questions for Mr. Leahigh.
THE COURT: All right. Thank you.
MS. JAISWAL: You're welcome.
Q. Mr. Leahigh, you did not present any water cost analysis for Dr. Hanson's tier two and tier two proposal; is that correct?
A. That's correct.
Q. And that's because you couldn't determine what would be required under Dr. Hanson's tier two and tier three proposal; is that correct?



A. Well, the analysis could probably be done. We haven't had an opportunity to complete it.
MS. JAISWAL: Thank you.
THE COURT: Thank you very much, Ms. Jaiswal. Mr. Maysonett.
MR. MAYSONETT: Your Honor, I just have a handful of questions.
THE COURT: All right. You may proceed.
CROSS-EXAMINATION
BY MR. MAYSONETT:
Q. Mr. Leahigh, who operates the reservoir at New Melones?
A. Bureau of Reclamation.
Q. And do you know what operational restrictions make just on Bureau of Reclamation's operations at New Melones?
A. No, I'm not familiar with all the water rights restrictions.
Q. Do you know whether or not the Bureau of Reclamation has discretion to release water freely from the New Melones Water Reservoir?
A. No, I don't believe they do.
Q. And Mr. Leahigh, can you tell me who operates the Don Pedro Reservoir?
A. I'm not sure exactly, but I believe Turlock Irrigation District possibly, Modesto ID.
Q. But it's not the California Department of Water



Resources --
A. It is not --
Q. -- or the Bureau of Reclamation; is it?
A. No, it is neither of the project agencies.
MR. MAYSONETT: Thank you, Your Honor. I don't have any questions for Mr. Leahigh. I would say only as a result of the fact that the state and federal governments were restricted to two witnesses, as Mr. Lee explained, they relied on our biologist and we have relied on Mr. Leahigh as the operator.
We do have Mr. Milligan here in the courtroom. He is available for the Court if you have further questions for the details of CVP operations or if you conclude that these questions about reservoir operations are critical. But I understand that in the interest of time, it won't be possible to present them both.
THE COURT: Thank you very much, Mr. Maysonett. Mr. Wilkinson.
MR. WILKINSON: Your Honor, I had a few questions, but I frankly think there's nothing so earth shattering there that I have to take the time to do it. I'm going to waive in the interest of having this proceeding completed today.
THE COURT: Thank you very much, Mr. Wilkinson. Mr. O'Hanlon?
MR. O'HANLON: Your Honor, likewise, in the interest

of saving time and moving the proceedings along, I waive cross as well.

THE COURT: All right. Thank you very much. Is there any redirect?

MS. WORDHAM: Yes, Your Honor. Just very briefly.

REDIRECT EXAMINATION

BY MS. WORDHAM:

Q. Mr. Leahigh, would you please find the Federal Defendants' Exhibit Number 3 in front of you. This is the declaration of Cay Goude filed by the federal defendants on, I believe it was July 9, 2007.

A. Yes, I have it.

Q. If you will go to Exhibit 2, Attachment B of Ms. Goude's declaration.

Have you found that?

A. Yes, I have. I see it.

Q. Attachment B. Could you please describe that briefly?

A. Yes. Attachment B is a flow chart that is the -- identifies the specific process for ending action three and implementing action four.

Q. So in the -- one-third of the way in from the left-hand-hand column, there is a small box which indicates "start of action four" -- "start action four"; is that correct?

A. That's correct.



Q. And then there's an arrow pointing to the right; correct?

A. Yes.

Q. So if I understand this chart correctly, all the actions identified to the right of the box that says start action four would pertain to implementation of action four; is that correct?

A. Yes.

Q. And the boxes and diamond shapes in here describe what operations or how decisions would be made under plaintiffs' action -- or the service's action four; is that correct?

A. That's correct.

Q. If you follow the arrows to a conclusion, where, at the bottom right, not the diamond box, but the long rectangular box, it says, "Modify operations (footnote 1)." Is that correct?

A. That's correct.

Q. Turning to the footnotes for Attachment B immediately following the diagram, and going to footnote 1. Would you please read footnote 1 for the record.

A. Yes. "Operations of the two water export facilities will be modified in a manner similar to what is described in action three of Exhibit 2. Other actions may be taken that are found to appropriately avoid or minimize entrainment effects at the water export facilities."

Q. Now, when you estimated the water impacts, water costs



associated with the service's action four, you estimated a range of flows in Old and Middle Rivers at zero to negative 4,000 cfs; is that correct?

A. That is correct.

Q. And there is no specified flow in the chart, the action matrix itself, that says negative -- zero to negative 4,000 flows for action four; is that correct?

A. Correct.

Q. Did you rely on footnote 1 of Attachment B of Exhibit 2 to support your decision to include a flow objective of zero to negative 4,000 cfs in estimating your water costs for the service's action four?

A. Yes.

MS. WORDHAM: Thank you. No further questions.

THE COURT: Further cross?

MS. JAISWAL: No, Your Honor.

THE COURT: Ms. Jaiswal?

MS. JAISWAL: No, Your Honor.

THE COURT: Does any intervenor have any further questions for Mr. Leahigh?

MR. WILKINSON: No, Your Honor.

MR. O'HANLON: No, Your Honor.

THE COURT: May this witness be excused?

Thank you, Mr. Leahigh. You may step down. You are excused.



All right. I am going to ask Mr. Maysonett that we call Mr. Milligan for some brief questions.

MR. MAYSONETT: Yes, Your Honor.

MS. WORDHAM: Your Honor, I have one minor housekeeping matter if I might.

THE COURT: Yes.

MS. WORDHAM: During Mr. Leahigh's testimony, we offered an exhibit, order amending the Department of Water Resources Federal Energy Regulatory Commission license that was missing a page. We have since been able to obtain a complete copy of the order. I would like to substitute the order that was --

THE COURT: All right. If you would hand the original and duplicate to the courtroom deputy.

MS. WORDHAM: I will do that, sir.

THE COURT: And she'll give you back the old one and we can substitute the new one.

MS. WORDHAM: Yes, sir.

THE COURT: For the integrity of the record, let's keep the old one and we'll mark this as -- what was the old one? DWR Q, we'll make this DWR Q-1.

(Defendants' Exhibit DWR Q-1 was marked for identification.)

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RONALD MILLIGAN,
called as a witness on behalf of the Federal Defendants, having been first duly sworn, testified as follows:

THE CLERK: Please state your full name for the record and spell your last name.

THE WITNESS: My name is Ronald Milligan, last name spelled M-I-L-L-I-G-A-N.

EXAMINATION BY THE COURT

THE COURT: Please have a seat. You have just stated your name for the record. Can you tell us by whom you're employed?

THE WITNESS: I am employed by the US Bureau of Reclamation.

THE COURT: For how long?

THE WITNESS: Since -- since November of 1999.

THE COURT: What's your present assignment?

THE WITNESS: I am the operations manager for the Central Valley Operations Office in Sacramento.

THE COURT: Does that operations office at Sacramento include responsibility for operation of the Central Valley Project?

THE WITNESS: Yes, it does.

THE COURT: How long have you held this position?

THE WITNESS: Since November of 2004.

THE COURT: And have you had direct knowledge of the



work on the 2004-2005, what's referred to as the OCAP and the Biological Opinion that was prepared relative to that?

THE WITNESS: Not in the direct preparation, but upon its completion, we've been operating to that in part, within our other operations, since that time.

THE COURT: If I understand your answer, then you had no role in the preparation of any portion of the materials that comprised the administrative record or the Biological Opinion and the evaluation of the OCAP?

THE WITNESS: That is correct. That was completed -- at least the reclamation part of that, was completed before I took my position at the CVO.

THE COURT: Commencing in March of 2005, were you familiar with the process known as the DSRAM?

THE WITNESS: Yes, I was -- I am familiar with that.

THE COURT: And what is the basis for your familiarity?

THE WITNESS: Primarily working as a -- say the week to week operations of what's referred to as the Water Operations Management Team. I act as the co-chair for that group. And then the work with receiving the information from the Delta Smelt Working Group every fall depending on the fall midwater trawl that would trigger -- or other triggers as to when the Delta Smelt Working Group would convene and basically be apprised of what their discussions had been on a weekly



basis.

THE COURT: And so you had regular communication, including observation, of the delta smelt Working Group's activities in this, if you will, implementation of the DSRAM?

THE WITNESS: Not in their -- not directly to their deliberations, if you will, or their meetings. I have a staff person that's under my direction that attends typically to provide information to the working group along with a person from the state project. Provide them information about current operations and what projected operations would be over the next week, month. What standards in the Delta may be controlling at a particular time.

And then if there's any information or recommendations that may come out of that group, it would come then to the WOMT, who would then discuss those recommendations or those findings or information to see if there was any operational changes that would be appropriate for the coming week.

THE COURT: I'm not going to ask you to summarize it at all, but I am going to refer to testimony that has been given here by various biologists concerning the decline of the, if you will, health of the delta smelt species. You're familiar with that information?

THE WITNESS: Yes, I am.

THE COURT: And in the years commencing with 2005,



after these, the DSRAM, the DSWG and the WOMT were actually constituted and started their work, you've been on the WOMT, an active participant in that process?

THE WITNESS: Yes. Yes, I have.

THE COURT: Now, is it true that there were recommendations made in the year 2006 starting in the spring by the Delta Smelt Working Group that called for actions, protective actions to be taken with regard to delta smelt?

THE WITNESS: There were recommendations from the working group that started prior to that. But then they continued through the late winter into the spring. Is your -- are we going to talk about at all the earlier recommendations or findings or are we going to focus more on the later ones?

THE COURT: If you want to start with the earlier ones. I don't want to prolong this or extend it.

THE WITNESS: Sure.

THE COURT: But start with the earlier ones and then move into the 2006 water year.

THE WITNESS: Well, within the 2006 water year, there were some recommendations that were -- that were made in conjunction with some triggers about the hydrology. This last winter was dry, so there were several occasions where some of the -- some of the recommendations were not -- the trigger did not occur. Some of those were in the early winter months

where the trigger would have been, if I recall without having them in front of me, if we had flows on the Sacramento River near Rio Vista that would get above a certain three-day average, then a particular set of curtailments that may relate to Old and Middle River flows would come into play. Those triggers did not occur and there were no modifications to operations.

I think there were probably -- there was some times we certainly operate to Old and Middle River flows in January and February, we would continue to touch base week to week. If I recall, the management to Old and Middle River was in the range of about negative 5,000. I think there was a time that may have been near 4,000, negative 4,000. I can't remember the exact dates. But it was in that range.

We had discussions back and forth, because this was a fairly new way of managing the central Delta's hydrodynamics. So we had some spirited discussions as to -- as to what's the proper averaging period, how the projects could -- what would be construed as being consistent with the recommendations or the spirit of them.

Because typically although both the USGS and the Bureau of -- USGS and the Department of Water Resources have some empirical equations that would predict an approximation in Middle and Old River flows, they do vary and they are -- there is some error bounds around those.



To get an actual measured reading from the USGS on those -- to get a middle and Old River flow takes several days, it's several days in arrears. And we found that when we're working, I think, if I remember correctly, a five-day averaging period. So we were trying to modify operations in terms of pumping and reservoir releases in the upper -- mostly in the Sacramento watershed to be able to maintain a negative Old River flow in a range that seemed appropriate.

But with the several days in arrears from the USGS, we were -- I won't say that we were struggling, but we were really looking to see and document what the response was to the gauges to different actions. And there were times that there were lags.

It was not instantaneous or one-day response to, let's say, a pumping curtailment or a reservoir -- or say a flow increase at -- let's say at Rio Vista, that -- or even at Vernalis, that would respond very quickly. So -- and there would be some swings. It wouldn't be a smooth transition either. So we had some observations for further consideration if we were to use this as a tool in subsequent years.

THE COURT: Are you aware that in this case, the plaintiffs have referred to recommendations made in the spring, the late spring of 2006, action recommendations that then were communicated to the WOMT and ultimately resulted in no action being taken? Are you familiar with the plaintiffs'



claims about that?

THE WITNESS: Yes, I am.

THE COURT: And relative to the fact that no action was taken in regard to the Delta Smelt Working Group recommendations, would you say that that was accurate or not accurate?

THE WITNESS: There were some -- there were some -- I'm trying to find the right word. There were some actions that were referred to as recommendations by the Delta Smelt Working Group in the later -- let's say in the spring period, particularly, I believe, after the VAMP pulse, which was --

THE COURT: Yes.

THE WITNESS: -- delayed a week this year because of the size of hatchery fish within the San Joaquin River basin.

But as we were coming out of the VAMP period, there were some recommendations made. I do remember one in particular recommendation to keep cross-channel gate in an open position. That was, upon review, countered to both the Water Quality Control Plan, which would have necessitated an urgency change petition with the state board, and subsequent discussions with NOAA Fisheries, they were concerned about leaving it open because there were some out-migrating salmon in the system. So that is one aspect of a recommendation that was not followed.



There were certainly, later on, as it became apparent that both EWA assets or the ability for the EWA to function in a manner that it could, in essence, pay back the projects for curtailments without impacting operations in the long term sense or allocations to contractors, that -- this is my characterization of that circumstance. This situation was elevated to the director's level of each of the five agencies, meaning DWR, Bureau of Reclamation, NOAA Fisheries, Department of Fish & Game and the Fish & Wildlife Service.

There were discussions there about what should be done at that point because we had exhausted the typical asset set, if you will, that was described within the Biological Opinion and project description in the biological assessment.

The work that was -- after discussions at that level, it came back that the recommendation would be -- there would be some modification and continued assessment of the circumstances. But the -- the work of the Delta Smelt Working Group was taken certainly under advisement by the directors. But some subsequent changes in operations were -- came out of that particular sets of meetings. And some of those meetings were two or three times a week.

THE COURT: All right. And going into the '07 water year, you're familiar with the June actions where pumps were stopped --

THE WITNESS: Yes.

THE COURT: -- relative to both recommendations and conditions?

THE WITNESS: Pumping was curtailed significantly. I will use the example of at the Jones Pumping Plant in the Central Valley Project. We were at one unit pumping, which is one of the large pumps there with the capacity of 850 cfs, which started the beginning of the VAMP period. And that lasted for 31 days. And then we had another subsequent 19 or 20 days where we sustained our pumping at one unit.

The recommendation at the time, if I'm not mistaken, from the Delta Smelt Working Group was to try to achieve a zero Old and Middle River flow. Zero to positive. It was for a number of reasons that had been discussed about the hydrodynamics of the Delta and the pumping within the interior itself for non-project purposes, and also the base flow in the San Joaquin River after the pulse flow period, even if it was a critically dry year from the San Joaquin River basin.

Even if the project, both projects had cut to zero, it was our assessment that a Middle and Old River flow of at zero could not be achieved. The Bureau of Reclamation assessed our particular demand for our project at the time and we assessed that some flow was necessary to -- for several reasons.

One, to maintain deliveries to the upper Delta Mendota Canal contractors, who would have -- in essence, some



portions of those districts had no other source of water that they could rely on quickly. Other portions of those districts would have had to begin pumping from the San Joaquin River to be able to meet some of their demands. Which would have further reduced the influence of the Delta, which would have further compounded the middle and Old River situation. The reclamation used some authorities that we had within the -- both within EWA and B3 of the Central Valley Project Improvement Act to make some purchases of water from known sellers to augment flows in the San Joaquin River to, if you will, compensate for the one unit operation at Jones Pumping Plant.

THE COURT: In your opinion, did the Bureau -- and let me ask one question foundationally before I ask that opinion. Is the WOMT, is that the final authority on whether or not a recommended action is going to be implemented or does it go higher?

THE WITNESS: The documentation of the WOMT is somewhat different in a couple of places. Typically WOMT will be representatives designated by the individual directors to represent them on a weekly basis. And that's ordinarily how we operate.

In other places, the WOMT, in essence, is the director's level. And that when we elevated a discussion of 22 directors, that is still really within the WOMT structure.



I will say that the project agencies, because they are the ones who actually have to issue the order to make a change, whether it's in the pumping or releases, ultimately have the final decision that's made about what is done. But in this case, most often it would be an extreme circumstance of some emergency where an agency would override, let's say, consensus of the WOMT.

THE COURT: Now, I'm going to ask for your opinion. Relative to the plaintiffs' claims that the Delta Smelt Working Group action recommendations for protection of the delta smelt were not followed or implemented, can you express your opinion about whether or not there was a response and whether actions were or were not taken in response to the recommendations?

THE WITNESS: In my opinion, as an observer and one who was providing some information to that collective group, and meaning at this point the director's level, who had recommendations from the Delta Smelt Working Group, that certainly the recommendations were taken very seriously for consideration. Those were balanced with other considerations of the other species, the economic effects of making changes or curtailing deliveries that occur at the time both from an M and I and an agricultural standpoint.

Considerations were given to the withdrawal rate at San Luis Reservoir. We've touched on that with some of the



testimony. And staying within a safe limit there without causing some major structural damage.

At that time we had several periods where O'Neill Forebay elevations were very low, which would have -- could have potentially triggered shutting off of the pump generation plant associated with that facility, which would have been interruption of supply.

So the projects collectively were operating as close as they could to the edge in terms of trying to minimize pumping as much as we could during this period. And also looking very carefully at what the salvage was at both facilities, trying to determine if any fish that were in the southern Delta were taking -- were being -- were being taken in. We had very little fish taken during this period at the Tracy fishery facility.

And there was a number of discussions about the dynamics of the Clifton Court Forebay and potential for some fish to -- whether they were maybe coming in from Old River into the forebay somehow before they got to the Tracy Fishery Facility or if they had been around in that area from some period of time before.

There was a great deal of focus on the temperatures in the southern Delta and the survivability of any juvenile smelt. Certainly continued observations of smelt distribution that came from the 20 millimeter trawls.

Initially there was some concern about the low numbers being such that it may not be readily apparent as to a distribution given the low numbers. But as we got into this, you know, four, six weeks at a time, the distribution -- a pattern of finding of the few fish that were found indicated that although it wasn't a strong indication of distribution, the distribution of the fish tended more towards the northern Delta out towards the bay.

THE COURT: Would you agree with the biological assessment that the status of the delta smelt is presently at a critical stage in terms of its jeopardy for survival?

THE WITNESS: I assume you mean that in a small b, small a, not a biological assessment as a document.

THE COURT: I'm sorry. You're exactly right.

THE WITNESS: Okay. Given -- again, this is not my area of expertise, I am an engineer.

THE COURT: I am looking to you as the executive who runs these operations.

THE WITNESS: Certainly as a concern to the Bureau of Reclamation that for the last three years, the fall midwater trawl, which we would agree from, at least my discussions with our biologists and those at the service, is the key indices on the smelt, to give us some indication of the status of the species.

We are very concerned about that. Reclamation,



beyond the operation of the projects, have invested in the Pelagic Organism Decline effort. We fund roughly half of that. Plus provide a number of key staff to participate in the 30 some odd scientific studies. Because there seems to be something that's happened in the estuary that has changed, probably since about the year 2000.

And to this point, we're not -- I don't think anybody can say that it is not entirely that the project has some effect because there is some hydrodynamic effect there. But there are a couple of other stressors in the system that have been discussed in court that we feel are worthy of investigation. And to get -- because we actually think if we were to just focus solely on the operations of the project, that we would see further declines potentially.

THE COURT: There isn't any question, as an operating executive, that you recognize your full responsibilities under the Endangered Species Act on behalf of the Bureau of Reclamation? Not asking for a legal conclusion.

THE WITNESS: I believe --

THE COURT: As an operator.

THE WITNESS: So. I will submit that Bureau of Reclamation, under my signature, requested reconsultation with the Fish & Wildlife Service based on the status of the species. And that was July of a year ago. July of '06. Reclamation, me and my office, who is responsible for



preparing the biological assessment, requested reconsultation. We've also requested reconsultation with NOAA Fisheries on our other opinion, and that's based more upon the listing of the green sturgeon and some critical habitat designation. But --

THE COURT: We don't have to have any concerns, any judicial concerns about the agency following the law.

THE WITNESS: No. We've also stated some 7(d) responses, if you will, that may not be the proper word. But under the -- let's say, we -- there's certain actions that we have indicated that they are going to put on hold and not commit long-term to until we have a re-worked re consultation Biological Opinion in place.

THE COURT: And are you familiar with the Fish & Wildlife Service proposed action matrix that has been presented in the context of these proceedings?

THE WITNESS: I am familiar with these.

THE COURT: And were that or some other remedy to be ordered by the Court, do you foresee any difficulties, impediments to the implementation of any such remedies?

THE WITNESS: I will say that all of the matrices of actions that I have seen would present some difficulties, yes, in operating the projects. Is there a reason that we could not do that, reclamation would make every attempt to find within its authorities to implement those actions and work in a coordinated matter with the state project.



In particular, for the Fish & Wildlife Service matrices, we believe that that is implementable, if that word makes sense.

THE COURT: It does.

THE WITNESS: Is that it could be done. It would be with significant effects, depending on the hydrology. Would it be beyond the current B2 EWA set of assets that -- as laid out in the biological assessment for the last opinion? It very well could. And reclamation would try to find other ways within its authorities to account for those effects as they are related to the CVP.

THE COURT: Thank you very much. Those are my questions. Do you wish to question, Mr. Maysonett?

MR. MAYSONETT: Your Honor, I don't have any followup questions in addition to the Court's unless there's some area that the Court would like me to --

THE COURT: Do the plaintiffs wish to address any questions to Mr. Milligan?

MS. POOLE: Two questions, if I may, Your Honor.

THE COURT: Yes.

CROSS-EXAMINATION

BY MS. POOLE:

Q. Good afternoon, Mr. Milligan, my name is Kate Poole, I'm an attorney for the plaintiffs. I have a clarifying question for you.

I believe that the judge was asking you about Delta Smelt Working Group recommendations and WOMT responses in two different time periods during this testimony you just gave. Spring, '06 and spring, '07. I understood your answer to be only addressing spring '07 operations. Is that correct?
A. That is not my recollection of our conversation just now. I think the two periods we spoke of were certainly the spring of '07, but I believe it was the earlier winter '07 that we were -- that I was referring to in terms of some actions that were contemplated by the Delta Smelt Working Group that were not triggered.
THE COURT: Did you mean to say winter '06?
THE WITNESS: Yes, I did. Well --
THE COURT: We haven't got to winter '07.
THE WITNESS: It was the January/February '07 that I'm referring to. There was some late -- there were discussions among these lines in December of '06. I don't -- I don't remember anything that we discussed that related to the spring of '06.
MS. POOLE: Thank you.
Q. And if I understood you correctly, I believe you just testified that during the period when the Delta Smelt Working Group recommendations were in place this May and June of '07, that the bureau was, quote, "operating as close to the edge as we could." Is that correct?



A. My reference to "close to the edge" in terms of operations were primarily south of Delta, withdrawals from San Luis Reservoir and the operational range within O'Neill Forebay.
Q. So you were not referring to Delta export rates from the bureau and Tracy pumps?
A. I think I mentioned that we had one pump unit going at 850 cfs, which is the minimum we can pump at that location. And that we were simultaneously at that time making purchases and having water released into the San Joaquin River to compensate for that. However, the collective hydrodynamics in the Delta did not allow for that combined operation or collective operations to get to the zero in middle and Old River flow.
Q. Thank you. In the second half of June, the bureau's pumping rate from banks ranged between over 2,000 cfs and close to 6,000 cfs; is that right?
A. I'm confused by your question because I'm not sure if you mean Jones Pumping Plant.
Q. I'm sorry. Yes, I do mean the Jones Pumping Plant.
A. I believe early in the month of June, there was a time that we transitioned up to a three-unit operation, which would probably be -- I'm not sure what the lower end of your range was that you discussed.
Q. 2000 cfs.
A. Approximately 2000. It probably was 2100 potentially. But probably a little over 2,000 cfs with three units in place



to be able to meet demands as they were also being elevated within the State Water Project. Not to delay or -- delay the answer, but the circumstances at the time were the State Water Project had for a period allowed the CVP to take more than its 47 percent share, if you will, of withdrawal from San Luis Reservoir.
Circumstances within the State Water Project south of that point necessitated that they needed to take a larger share of their withdrawal much closer to their 52 percent, 53 percent. So the -- at that time, again, under consultation with the directors of the five agencies, a decision was made to put several more units online at Jones Pumping Plant given the low salvage numbers at the Tracy fishery.
And the intent there was to monitor that very closely and see how that was to respond. And as we got closer to the end of the month, as temperatures rose in the south Delta, several more units were brought online.
Q. For a pumping rate of close to -- of more than 4,000 cfs; is that right?
A. Our five unit operation would have been at 43 to 4400 cfs.
MS. POOLE: Thank you, Mr. Milligan.
THE COURT: Mr. Lee, Ms. Wordham, does the DWR have any questions?
MR. LEE: We have no questions.
THE COURT: Thank you. Mr. Wilkinson, any questions?



MR. WILKINSON: Yes, Your Honor, I do have just a couple of questions.
CROSS-EXAMINATION
BY MR. WILKINSON:
Q. Mr. Milligan, I believe you testified that part of the action matrix requires the maintenance of a zero cfs or a potential zero cfs flow in Old and Middle River at certain times of the year?
A. I believe several of the matrices have that as one end of the bounds, yes.
Q. And was it your testimony that maintaining a zero cfs flow would be difficult for both the state and federal projects?
A. Thinking of the projects combined overall, during periods where the San Joaquin River inflow at Vernalis is low and there is, let's say, at least some degree of pumping by in-Delta diverters, and particularly at times where the tide cycle was such coming from the neap tide to the spring tide that, as Mr. Leahigh referred to, is the kind of filling of the Delta, if you will, that a very low Middle and Old River flow, whether it's negative 1,000 or down to zero or even trying to achieve positive, is probably beyond the ability of the projects, within their pumping.
Q. Is it also true that there are diversions made by the Contra Costa Water District and agricultural diversions on Old and Middle Rivers as well?

A. When I referred to in-Delta diversions, those are the two primary areas. Both the agricultural diversions and also Contra Costa's pumping.
Q. If you were required to meet a zero flow in Old and Middle River, and you already had your project pumps shut off, how would you try to meet that flow?
A. Realizing that modifying the tides toward -- the meteorological condition that might also affect, low pressure systems, winds, storm surges that were a concern at the time, one might send -- I believe, that the State Board actually sent out letters to those diverters asking them to curtail as much as they could. The only other option that the projects might have available to them is finding water on the San Joaquin River, whether it's in the form of rolling cellars or, in the case of reclamation, potentially operations at New Melones to provide additional flow into the San Joaquin River.
Now, New Melones, as a point in fact, for the coming year would be very difficult. Reclamation doesn't have any extra water, so to speak, within New Melones.
Q. Even if you were able to follow one of those actions, Mr. Milligan, do you have any assurance that doing so would result in zero flow in Old and Middle River?
MS. POOLE: Objection. Incomplete hypothetical.
THE COURT: Do you have enough information to answer this question?



THE WITNESS: I would probably ask as a hypothetical, if you could add just a little more detail to that.
THE COURT: All right. The objection is sustained.
BY MR. WILKINSON:
Q. Mr. Milligan, are you aware that the Department of Water Resources has made one change to the proposed Fish & Wildlife Service action matrix?
A. I am aware that within Mr. Johns declaration, he has proposed -- I would have thought changes. I'm not aware there's just one change. But I'm aware --
Q. Let me ask you --
A. I am aware of a change.
Q. Let me ask specifically. Are you aware that the Department of Water Resources has suggested that the zero flow, the lower end of the range in the Fish & Wildlife Service action matrix, action number three, be changed to a negative 1500 cfs.
MS. POOLE: Your Honor, I'm going to object. This is beyond the scope of any direct testimony.
THE COURT: I'm going to overrule the objection. I'll permit the witness to answer this question. This is about a proposed remedy and feasibility of implementation. This would be one of the implementing agencies. You may answer.
THE WITNESS: I am aware of that suggestion.



BY MR. WILKINSON:
Q. I'm sorry, Mr. Milligan. Did you complete your answer?
A. I am aware of that suggestion from Mr. Johns' declaration.
Q. As project operator, Mr. Milligan, would you support that change?
A. From a -- from the context of treating these tables as -- let's say the same par as the tables that we've been looking at from the D 1641, for example, I would certainly support making the lower range or the upper range, depending on your point of view, as achievable for the projects if possible.
I would probably also, as a steward of resources, probably say that that's probably, as a remedy or as a standard or as an objective, would be appropriate to move to a negative 1500. There probably are times on the reverse of the out -- of the water leaving the Delta, that it also seemed it was possible to add another level of protection that would be maybe a reasonable thing to do, depending on the input from the biologists.
MR. WILKINSON: Thank you very much.
THE WITNESS: But as an objective, I would say negative 1500 would be -- would allow the projects the greater ability to actually meet what's being asked of us.
MR. WILKINSON: Thank you very much. I have no further questions.



THE COURT: Mr. O'Hanlon.
MR. O'HANLON: Yes, Your Honor.
THE COURT: Do you have any questions?
MR. O'HANLON: Yes, Your Honor.
CROSS-EXAMINATION
BY MR. O'HANLON:
Q. Mr. Milligan, since you joined the Bureau of Reclamation, how much money has the Bureau of Reclamation spent on efforts to protect the delta smelt?
MS. POOLE: Objection. Beyond the scope. And also calls for economic costs.
THE COURT: All right. I will allow the question to be answered for the limited purpose of showing any action by the agency to respond to the status of the species as threatened or endangered. You may answer.
THE WITNESS: I am afraid that I am not fully aware of all the budgetary costs that may have gone into doing that. I'm not entirely sure if you are referring to just monetary budgetary-wise or, let's say, water costs.
BY MR. O'HANLON:
Q. Let me modify my question then, given your area of responsibility. Since you joined the Bureau of Reclamation, how much water has the Bureau of Reclamation dedicated to efforts to protect the delta smelt?
A. Whether directly or indirectly, I would some -- I have

seen some indication of, at least indirectly, virtually all the B2 assets that are spent in the course of a year have some benefit to delta smelt. So whether it's meeting the incremental Water Quality Control Plan costs above Decision 1485 in the Delta, to some degree the fall releases that may primarily be for the benefit of the salmon species or steelhead species in CVP controlled rivers and streams.

Some might say that the cold water releases in Clear Creek may have very little effect on delta smelt. We've never tabulated it that way. But I would say at least a very high majority of the B2 water that's used in a given year has at least an indirect benefit to smelt.

THE COURT: And is that approximately 800,000 acre feet you're referring to or some different quantity?

THE WITNESS: The 800,000 I'm speaking to. Now, some piece of that, Clear Creek flows may have a very minimal and some might argue no effect. But that's not the large -- that's not a majority of that water, even a large portion.

BY MR. O'HANLON:

Q. So can you give us --

A. I guess I'd add to that, reclamation does also provide funding to the Environmental Water Account, both from a staffing perspective, and then also as budgetary constraints allow also for the purchase of water for EWA. Many of those



actions are also for the benefit of smelt, either directly or indirectly.

Q. Can you give me an estimate -- of 800,000 acre feet dedicated under B2, can you give me an estimate of approximately how much of that water is dedicated annually for delta smelt measures or that benefits delta smelt indirectly?

MS. POOLE: Objection. Asked and answered.

THE COURT: Is there a different figure from what you've just stated?

THE WITNESS: I am -- I am searching to see if I can try to make an attempt to quantify, let's say Clear Creek flows, let's say above 700,000 I would say.

THE COURT: Thank you.

MR. O'HANLON: Thank you, Mr. Milligan. I have no further questions, Your Honor.

THE COURT: All right. I have no further questions. Do the plaintiffs have any recross?

MS. POOLE: Two questions, Your Honor.

RECROSS-EXAMINATION

BY MS. POOLE:

Q. Mr. Milligan, I believe you just stated that meeting the D 1641 salinity standards benefit delta smelt as assisted by the B2 releases. Would additional fresh water outflows to the Delta benefit delta smelt?

A. Beyond what's in D 1641?



Q. Yes.

MR. WILKINSON: I'm going to object on the basis it's beyond the area of expertise.

MS. POOLE: The witness just testified that --

THE COURT: Yes. I'm going to overrule the objection. As an operator, he can answer in the context of his operational responsibilities in performance of his duties. Not as a biologist. You may answer.

THE WITNESS: To help me formulate my answer, will you please repeat the question, so I --

THE COURT: Read it back, please.

(Record read as requested.)

THE WITNESS: I will say as an operator that -- let's say an increased net Delta outflow index would move the X2 position further to the Golden Gate. To the degree to which that would be moved and to the degree that that would provide additional habitat, I could not tell you given the current population levels that that is a significant -- or would benefit the population significantly. That would be beyond my expertise.

MS. POOLE: Thank you, Mr. Milligan. That's all, Your Honor.

THE COURT: Anything further, Mr. Maysonett?

MR. MAYSONETT: I have nothing further, Your Honor.

THE COURT: Mr. Lee?



MR. LEE: No, sir.

THE COURT: Mr. Wilkinson?

MR. WILKINSON: No, Your Honor.

THE COURT: Thank you, Mr. Milligan. You may step down.

THE WITNESS: Thank you.

THE COURT: You're excused.

Does any party have any further evidence?

MR. WALL: Your Honor, we have a very brief rebuttal. I think it will take about five minutes.

THE COURT: Proceed.

MR. WALL: Dr. Swanson, if you'd come forward.

THE COURT: You're still under oath, Dr. Swanson.

THE WITNESS: Thank you, Your Honor.

CHRISTINA SWANSON,

called as a rebuttal witness on behalf of the Plaintiffs, having been previously sworn, testified as follows:

THE COURT: Mr. Wall, you may proceed.

DIRECT EXAMINATION

BY MR. WALL:

Q. Dr. Swanson, there's going to be a stack of papers in front of you. And if I could ask you to find Plaintiffs' 19, which I'll put on the Elmo.

A. Could you describe it for me, please?

Q. Should be on your screen.

A. Yes.
Q. This is plaintiffs' 19 for identification. Are you familiar with this document?
A. I am.
Q. Could you describe it, please.
A. This document shows three graphs which plot daily delta smelt salvage rates at the two facilities combined for the months of December, January, February and March for the years December, 1999 to -- through March 2000. December 2000 through March 2001 and December 2001 through March 2002. The -- below the graphs, I have also -- is also shown the average monthly Old and Middle River flow for those months.
Q. How did you come to become familiar with this document?
A. I created this graph.
Q. How did you create it? Where did you get the data from?
A. I used the data from the Central Valley Operations website for daily salvage rates for delta smelt and I used data from the US Geological Survey sensors in Old and Middle River to calculate daily flows for Old and Middle River from which I calculated the monthly averages.
MR. WALL: Your Honor, I move that Plaintiffs' 19 be entered into evidence.
THE COURT: Any objection?
MR. WILKINSON: No objection.
THE COURT: Exhibit 19 is received in evidence.



(Plaintiffs' Exhibit 19 was received.)
BY MR. WALL:
Q. Dr. Swanson, your proposed remedies in this proceeding call for monitoring of larval juvenile smelt at the project export facilities; correct?
A. That is correct, yes.
Q. Were you here for the testimony of Dr. Hanson?
A. Yes.
Q. And do you recall Dr. Hanson testifying regarding whether he thought that monitoring was necessary or not?
A. Yes.
Q. Do you have a view on the necessity or the importance of monitoring for larval smelt at the project export facilities?
A. In my judgment, monitoring for larval delta smelt represents an essential component necessary for us to be able to protect the delta smelt in this interim period. And I believe into the future.
We currently have inadequate information for us to evaluate the risk of entrainment for this early lifestage of delta smelt and, given the current low population abundance and the limited detection ability of our existing surveys, we cannot rely on those.
Particle Tracking Model can only get you so far, especially if you don't know where the larval delta smelt are. And current monitoring at the two export facilities does not



detect, measure or count delta smelt smaller than 20 millimeters in length.
Q. Dr. Swanson, were you here for the testimony of Dr. Miller?
A. I was.
Q. Do you have any response to his testimony?
A. I remain concerned about the analyses and interpretation that Dr. Miller presented in regards to his efforts to understand what are the driving forces controlling delta smelt population abundance.
Dr. Miller's principle conclusions, I have two general responses. One is Dr. Miller appears to view the only -- the only aspect of water project operations that he considers in his analyses appear to be related directly to water export operations.
And I think it's extremely clear that operations of the two water projects and their impacts on delta smelt and delta smelt critical habitat are far greater than that. And therefore, analyses that focus exclusively on exports are not particularly useful, particularly with reference to trying to determine how we need to modify operations to minimize their adverse impacts on the species and its critical habitat.
With regard to his analyses of the effect of zooplankton density on delta smelt population abundance, I continue to find those analyses highly questionable with



regard to his statistical techniques and I think they represent another example of Dr. Miller's selective use of data.
And I'll just give one example for that. And that is in his analyses to determine whether or not the availability of zooplankton food for delta smelt is a limiting or critical or driving factor for delta smelt population abundance, he has limited his analysis to looking at just two of the copepod species which are present in the Delta. Eurytemora and Pseudodiaptomus.
He has actually also admitted that one of those species is, in fact, no longer present in the Delta and ignores the fact that we know delta smelt eat many more copepod species than just those two. That alone is enough to provide a lot of questions as to how he can interpret those analyses.
Q. Dr. Swanson, you mentioned --
THE COURT: Did you mean to say that there are known species of zooplankton that exist that are present in the water column that are not included in the analysis?
THE WITNESS: Yes, that is correct, Your Honor, at least several.
THE COURT: And the inference that the expert would have the Court draw is that there are only two sources of food present in these zooplankton for the delta smelt?

THE WITNESS: His analysis examines only the abundance of those two zooplankton species with regard to delta smelt and ignores the fact that we know, based on gut content analysis, that delta smelt eat many more species than just the two that he included in his analysis.

THE COURT: And can you identify some of those?

THE WITNESS: I will hope to pronounce the names correctly. One of them is Limnoithona.

THE COURT: Help the court reporter, please.

THE WITNESS: That's, oh, my goodness, L-I-M-N-O-I-T-H-O-N-A.

Another one is called Acartiella, and I'm probably going to spell that one wrong, but I think it's A-C-A-R-T-I-E-L-L-A.

And after that, I'm running out of species names, Your Honor.

THE COURT: Thank you. You may proceed.

BY MR. WALL:

Q. Dr. Swanson, is the abundance of any of the species of zooplankton on which delta smelt feed increasing?

A. Yes. The abundance of Limnoithona has increased dramatically in recent years.

Q. And that's a time period when delta smelt population has declined; correct?

A. Yes, it is.



Q. Dr. Swanson, you testified that you were here for the testimony of Dr. Hanson. Do you recall him mentioning new survey data that's come out?

A. Yes, I do.

Q. And that's new survey data from the Summer Townet Survey; am I correct?

A. Yes.

Q. Have you become aware of this new survey data since your earlier testimony a few days ago?

A. Yes, I have.

Q. Could you briefly describe for us what the new Summer Townet Survey data shows?

A. Yes. Last night I went on to the internet and I accessed the website of the Department of Fish & Game and reviewed the most recent data from the Summer Townet Survey. I've written myself a little note. A cheat sheet with some of the results, which I hope is okay. The summer townet typically consists of --

THE COURT: If you don't have any independent recollection and you need to refer to the notes to refresh your recollection, it's okay.

THE WITNESS: Thank you, Your Honor.

THE COURT: That is the case?

THE WITNESS: Could you --

THE COURT: Do you need the notes to refresh your



recollection?

THE WITNESS: Yes. Thank you, Your Honor.

THE COURT: You may proceed.

THE WITNESS: The Summer Townet Survey consists of six sequential surveys. At the point where I prepared my testimony and my declarations, four of those had been completed. Or the results for the four were up. And they now have completed surveys five and six. And the numbers of delta smelt found in these last surveys is extremely low.

And, in fact, the other thing that I find equally disturbing is that the numbers of different stations, sampling stations within the Delta that are surveyed by the townet survey, the numbers of stations at which delta smelt are being detected is extremely low.

For example, the fifth survey of the 2007 Summer Townet Survey found delta smelt at just two of more than 20 stations sampled. And the sixth survey found delta smelt at only one survey and, in fact, only found a total of five delta smelt. The total number of delta smelt collected in the six surveys for 2007 summed to 55 fish. This is compared to A2 fish --

Q. If you could just pause and I'll write those down on the Elmo.

A. Certainly.

Q. If you could tell us the number of delta smelt found in



the first six surveys, Summer Townet Surveys in 2007.

A. 55 delta smelt were collected in 2007.

Q. And do you have that information for 2006?

A. I do.

Q. What is that?

A. 82 fish.

Q. Do you have that information for 2005?

A. Yes. It was 119 fish.

Q. How about for 2004?

A. In 2004, 189 fish were collected.

Q. Do you have that information for 2003?

A. Yes. In 2003, 338 delta smelt were collected.

Q. Do you have information on the number of stations at which delta smelt were found by the first -- or the sixth Summer Townet Survey in each of those years?

A. Yes. For survey number six, which would you like, in 2003? Delta smelt were found at six stations. In 2004, they were also found at six stations. In 2005 -- oh, I beg your pardon. 2004 is four stations. In 2005, they were found at five stations. In 2006, they were found at five stations. And in 2007 for survey number six, they were found at only one station, which was located in the lower Sacramento River near Decker Island.

Q. Dr. Swanson, do you have any conclusions from this new data?

A. As I testified earlier, both the abundance and distribution of a species are critical indicators of its risk of extinction and population status. I think these new data, they have re-emphasized my very high level of concern for the species because they indicate that, in fact, the population is in decline compared to last year and all previous years. And, in fact, the distribution of the species is becoming much more limited.

And I think the new data reemphasized the very high risk of extinction for the species right now. And re-emphasized, in my judgment, the critical need to implement all possible actions to minimize and hopefully eliminate, to the extent that we can, the adverse impacts of water project operations both on the fish itself, in terms of direct lethal take at the facilities, as well as the adverse impacts of operations on its critical habitat, including, during this period when the fish is distributed in low salinity brackish water habitat, beyond the direct influence of the pumps, but, in fact, that habitat is being affected by water project operations.

Q. Dr. Swanson, where was the one station where delta smelt were found in the sixth Summer Townet Survey this year?

A. It was located on the lower Sacramento River near Decker Island. I do not recall the station number.

Q. And is that the Delta smelt's preferred habitat for this



time of year?

A. Typically at this time of year delta smelt are distributed in low salinity habitat, wherever that habitat is in the Delta. Under most conditions, and certainly in the recent and historical past, that habitat would have been located further downstream in the Delta beyond the confluence and Suisun Bay because outflows would be higher than they are right now.

Q. Do these new survey data have any implications for your proposed action number ten, the fall action?

A. Our fall action was developed based on scientific research conducted by DWR scientists that show that during the fall, the September through December period, the quality and quantity of delta smelt habitat was determined in part by salinity and, in particular, outflows which drive the location of low salinity habitat preferred by delta smelt.

The location of low salinity habitat right now, on the basis of outflow in X2, is at approximately 85 to 89 kilometers. Analyses of the results of that research conducted by DWR scientists on habitat quality that were followed up by work by scientists on the Delta Smelt Working Group, some of whom are the same scientists, showed that habitat quality, which they defined using these three water quality metrics, was, in fact, related to the location of X2 or the location of low salinity habitat. And they found that when low salinity habitat was located upstream of 80



kilometers, comparable to where it is located right now, that overall habitat quality for delta smelt was low.

Our fall action was designed to increase Delta outflows and to shift the location of low salinity habitat downstream to or downstream of Kilometer 80. And those locations, the quality of habitat, as defined by this habitat quality index developed by these scientists, is better than it is where -- compared to where it is currently located right now. Our action was designed to achieve these conditions.

Q. Dr. Swanson, is it your understanding that the location of X2 is regulated by operations of the CVP and SWP reservoir facilities?

MR. WILKINSON: Your Honor, I wonder if I could interrupt just for a moment. Yesterday Mr. Wall was asked what the length of his rebuttal testimony was going to be and he said 15 minutes. This afternoon he told us it was five minutes. We've now gone three times that length of time. And I want to assure the Court I did not waive my cross-examination of Mr. Leahigh in order to allow Mr. Wall to expand his rebuttal testimony of Dr. Swanson. So I'd appreciate an accurate estimate of what the rebuttal time is going to be.

MR. WALL: This is my last question, Mr. Wilkinson.

MR. WILKINSON: Thank you.

THE COURT: Thank you.



MR. WALL: Except for getting the document admitted into evidence.

THE COURT: All right.

MR. WALL: Could you read back my question, please?

THE COURT: Yes, you may.

(Record read as requested.)

THE WITNESS: It's a combination of the operations of the reservoir facilities and the Delta export facilities.

BY MR. WALL:

Q. Dr. Swanson, I put on the Elmo a piece of paper on which I was doing my best to scribble down the numbers that you gave me for the number of delta smelt found in the three surveys, the Summer Townet Survey, the number of stations delta smelt were found in that survey. Is that -- did I scribble those numbers down accurately?

A. Yes.

Q. Your Honor, I can mark this piece of paper as Plaintiffs' 30 and I'd like to ask it be moved in evidence.

THE COURT: Is there any objection?

MR. WILKINSON: None, Your Honor.

THE COURT: Exhibit 30 is received in evidence.

(Plaintiffs' Exhibit 30 was received.)

MR. WALL: Thank you, Your Honor. That's our rebuttal testimony.

THE COURT: Mr. Maysonett, do you wish to

1 cross-examine?
2 MR. MAYSONETT: Just a moment, Your Honor.
3 Your Honor, in the interest of time, we're going to
4 waive cross-examination.
5 THE COURT: Mr. Lee?
6 MR. LEE: Similarly in the interest of time, we're
7 going to waive cross-examination.
8 THE COURT: Mr. Wilkinson.
9 MR. WILKINSON: No questions, Your Honor.
10 THE COURT: Mr. O'Hanlon?
11 MR. O'HANLON: No, Your Honor.
12 THE COURT: It appears that the examination on
13 rebuttal of the doctor is complete.
14 Thank you, Dr. Swanson. You may step down. You are
15 excused.
16 Does any party have further evidence?
17 All right. That then concludes the taking of
18 evidence in this proceeding. We are now at the hour of 2:45.
19 And we had planned to allocate three hours to argument and
20 half an hour for the Court to announce a decision. That would
21 take us to some time after 6:30 p.m. And as I have previously
22 indicated to the parties, I do not ask the Court staff -- I
23 stay, but I don't ask the Court staff to stay after the hour
24 of five p.m. and they aren't necessarily in the position to do
25 that. Plus the building closes now at five p.m. and the Court



1 security officers, as I understand it, leave only a skeleton
2 staff. And although I think you will now notice that the HVAC
3 has come on in the room, to our mutual comfort, after five
4 they turn the HVAC off in the building. So that might also be
5 a limiting factor.
6 So I am going to propose that you try to attenuate
7 your presentations here to that which is ultimately essential
8 and that we try to make our way through this by 5:30 p.m.
9 We're going to have to give the court reporter breaks because
10 this testimony has been very rapid, it's very complicated and
11 it's very, very difficult to take, as you all know.
12 So at this point, we can simply take the time and
13 mathematically divide it, we'll all reduce our respective
14 shares of the time that's left.
15 MR. WALL: Your Honor, that would be acceptable to
16 us. It would be, if I calculate correctly, a little bit more
17 than half an hour for each of the three groups. It would help
18 me focus my testimony if the Court gave some indication of the
19 areas of its greatest interest. If the Court would like me to
20 make that decision, I'm happy to try to do it.
21 THE COURT: All right. Let me say this to all of
22 you. You don't need to talk about the law. I understand the
23 law and I'm going to cover the law in my decision. And so
24 what I think we need to focus on is the seminal issues that
25 have been raised.



1 First of all, the status of the species as to how
2 critical jeopardy is, both to its survival and recovery and to
3 the impacts on its habitat of current and future conditions.
4 We are focused on, as part of that analysis then,
5 what the present, if you will, information -- and that's
6 mathematical quantitative information -- shows us on the
7 nature and extent of the distribution of the species.
8 The intervenors have raised issues about causes for
9 decline and they have -- and I think, by way of tentative
10 rulings, so you can direct your arguments, as I see this now,
11 Dr. Hanson, even Dr. Miller and all of the -- Mr. Milligan,
12 the operator for the action agency, nobody is arguing that the
13 species is in critical status.
14 And the question, I guess, is how does that translate
15 into the legal term of jeopardy. And there is, in the NMFS
16 case, a very specific definition of jeopardy that the Ninth
17 Circuit has very recently promulgated. It's a 2006 case.
18 And so the intervenors, primarily San Luis and Delta
19 Mendota Water Association and Westlands have essentially said,
20 well, we've got a problem here, but it has nothing to do with
21 the project operations and nothing to do with, in effect,
22 what's going on except as may be related to causes other than
23 water operations. I think that's a trial strategy that you
24 selected and that you have proceeded on.
25 I will tell you simply that in light of the



1 scientific evidence that's been presented on both sides, that
2 evidence doesn't preponderate.
3 And so in terms of the requisite foundational
4 elements of the critical jeopardy and the status of the
5 species and the threats to the deprivation of its habitat are
6 found to exist, then we are essentially on to the question of
7 what remedy is going to be necessary in the interim because
8 that then leads us to three more legal than factual issues.
9 And that is the agency has requested, as have all the
10 parties who are opposing the plaintiffs, they have requested
11 that, one, there be a remand. Well, there's no doubt there's
12 going to be a remand, the law requires it and there has to
13 be -- in effect, there's already been reinitiated consultation
14 as Mr. Milligan indicated to us.
15 And so the question then becomes all the parties have
16 requested that there be no vacatur of existing Biological
17 Opinion. However, again, by way of tentative ruling, what you
18 have is you have the indication of every expert who has
19 testified, there is no controversy or dispute among any expert
20 that at the current time the take limits are inadequate.
21 And we don't have to worry about the Biological
22 Opinion because that's been ruled unlawful and so that is the
23 operative status. We have an illegal Biological Opinion with
24 take limits that are admitted by all experts in this case who
25 are biologists and have the competence to say so, it's

1 inadequate to protect the species.
2 And given the requirements for the establishment of
3 the take limit, there isn't any party in this case who
4 provided us any legal authority on what we do about that in
5 terms of whether there is vacatur or non-vacatur of the
6 Biological Opinion and the take limits, when the evidence
7 tells us that the take limits aren't legally or actually
8 factually sufficient to protect the species. And so you
9 better spend some time on that.
10 And that will lead us then to remedies. And we have,
11 as I see it, the plaintiffs' ten element action. I'm not
12 going to call it a matrix because they haven't called it a
13 matrix. Their ten proposals, action proposals I'll call it.
14 I believe that's how Dr. Swanson has referred to them.
15 We have the Fish & Wildlife Service's five point
16 action matrix, they do call it a matrix so I'll call it a
17 matrix. It is proposed to be amended, it's not under Robert
18 Rules of Order, but as I understand it, DWR would like to
19 modify it in accordance with Mr. Leahigh's testimony this
20 afternoon.
21 Then we have Dr. Hanson for the State Water
22 Contractors who has proposed a three-tier approach which I
23 think essentially we can fold in to the Fish & Wildlife
24 Service as proposed to be modified by DWR.
25 And Mr. O'Hanlon has indicated that these Delta



1 Mendota and Westlands parties have some proposals, but
2 candidly, I've kind of lost them or maybe I don't understand
3 them in what we've been going through. So you can tell me
4 about those if you think they're going to add anything.
5 Otherwise it would be more productive for you to
6 focus on the other remedies that are proposed and tell me
7 what's wrong or right about any of them because that's going
8 to be most helpful. And then if Mr. Buckley is going to be
9 taking some time, hopefully this gives us clear direction.
10 That's what I'd like to hear from you about. Does
11 that help?
12 MR. WALL: That does, Your Honor. And I'm sure the
13 Court will feel free to give me further direction as I
14 proceed.
15 THE COURT: Yes. A break first says the reporter and
16 she's the boss. So we're going to stand in recess until 10
17 minutes after three.
18 (Recess.)
19 THE COURT: We're going back on the record in NRDC
20 versus Kempthorne. Please be seated.
21 All right. We are going to now hear from the
22 plaintiffs. Bear with me one moment. Mr. Wall, you may
23 proceed.
24 MR. WALL: Thank you, Your Honor. Your Honor, the
25 delta smelt teeters precariously on the edge of extinction.



1 We don't know exactly why. We don't know the exact population
2 level. But we do know that the species could go extinct
3 within the next year. We also know, without any dispute, that
4 the Central Valley Project and the State Water Project
5 operations, both at the export facilities and in their
6 management of flow through the Delta, are killing delta smelt
7 and adversely modifying its critical habitat.
8 Your Honor, this proceeding is not about assigning
9 blame or determining relative causation. The sole question
10 here is whether, in the face of considerable scientific
11 uncertainty, the defendants have proven that their proposed
12 operations will be deepen the jeopardy of delta smelt and will
13 not stand as an obstacle to this fish swimming back from the
14 edge of the cliff of extinction toward recovery.
15 Your Honor, by every reliable scientific measure, the
16 Delta smelt's population has crashed. All four indices by
17 which state and federal agencies measure smelt abundance have
18 set record lows. Delta smelt are hard to find in areas of the
19 fishes' critical habitat where they once thrived. These facts
20 are not disputed.
21 We also know that the geographic dispersion of the
22 delta smelt has been reduced. As Dr. Moyle and Dr. Swanson
23 testified, the delta smelt once spawned throughout both the
24 northern Delta and the southern Delta. No more. In 2007, the
25 delta smelt spawned only in the Sacramento River in a tiny



1 part of their historic range. And as the recent Summer Townet
2 Survey indicates, they remain confined at this time to a tiny
3 part of their historic range.
4 This is a critical condition for the delta smelt. As
5 Dr. Moyle explained, when the fish are concentrated in one
6 small place, they are vulnerable to any environmental
7 catastrophe, they only have one population. As Dr. Moyle put
8 it, they have no backup or insurance policy.
9 Your Honor, the diversity of this species has
10 diminished as well. Delta smelt spawn over several months.
11 But according to the recent findings of Dr. William Bennett,
12 on whose research all of the parties here have relied to some
13 extent, the only delta smelt that are surviving to reproduce
14 at present are those delta smelt hatched during the period of
15 VAMP. Months of delta smelt on either side -- yes.
16 THE COURT: Excuse me just one second. I'm going to
17 ask the court security officer -- what we'll do is if it
18 appears that we don't have enough seating in the courtroom,
19 those of you who are standing can take seats in the jury box.
20 We'll let the court security officer help you do that if you
21 wish. Otherwise try to find seats for them.
22 I'm sorry for the interruption, Mr. Wall.
23 MR. WALL: Should I continue?
24 THE COURT: Please.
25 MR. WALL: Literally months of delta smelt that are

hatching before and after VAMP are disappearing from the population.

Now, when thinking about the question of jeopardy, one naturally asks the question how many delta smelt are left. And the most we can say about that is that no one really knows. The only published peer review literature that contains a population estimate is that of Dr. Bennett. And he estimated, for 1994, a population of 86,000 delta smelt give or take about 86,000. In other words, he didn't know. And he acknowledged that the assumptions he made were not reliable.

There have been population numbers put forward in the course of this trial. 1.8 million juvenile smelt. 600,000. But Dr. Hanson's testimony put those estimates in perspective. As he explained, and I'm quoting here, "A million fish may sound like a lot to a layperson. In the context of a pelagic species like delta smelt, a million larval and early juvenile fish is a remarkably low number."

Your Honor, the species is not only in jeopardy, it is at the tipping point. Every day seems to bring new bad news. Dr. Moyle, who is widely recognized as the leading expert on California native fishes and has been studying delta smelt for decades and began studying them because when he started they were easy to find, testified that, quote, we're at a point where we need every small smelt out there we can get to contribute to the survival of this species.



Ms. Goude told us that if the Biological Opinion she authored a year or so ago were carried out today, delta smelt could go extinct within a year. Dr. Hanson testified that, quote, given the extremely low population abundance levels conducting more sampling for delta smelt was too risky because it might cause take in the hundreds of fish. Quote, "take in the hundreds of fish," he said, "would certainly be high." This species could go extinct this year.

The question in this trial is whether the proposed CVP and SWP operations have the potential to tip this species a little bit further over that edge. They clearly do. And I think if the burden were on us, we would have carried it, but of course the burden is not on us. The operations of the projects affect delta smelt in various ways. They affect delta smelt by impinging on their habitat quality in the fall.

The projects regulate flow of water through the Delta in the fall, which in turn affects salinity, which, according to the findings of Feyrer, et al., scientists at the Defendant Department of Water Resources, affects delta smelt abundance. This study found that salinity levels in the Delta, that complement of their water quality index, explained 19 percent of delta smelt abundance.

Reduced fresh water outflows through the Delta changed the location and amount of low salinity habitat, moving it further away from the nutrient rich Suisun Bay



towards the deeper less protective upstream channels and, in particular, in the Sacramento River channel where those fish are now confined.

Those reduced outflows are caused when water is kept in storage or exported. The projects also affect the Delta smelt's habitat in the southern part of the Delta.

Your Honor, Plaintiffs' Exhibit 1 is a map of the Delta smelt's critical habitat. At present, the delta smelt find themselves right up here in the northern part of the Delta. And the testimony of Dr. Swanson and Dr. Moyle establishes that a good third of their critical habitat in the southern part of the Delta is entirely inhospitable to them because of operations of the export facilities.

THE COURT: Why don't you use the letter and number designation from the other map so that we'll have it for the record where the north part of the Delta is.

MR. WALL: Your Honor, I'm not sure this other map was admitted in evidence.

THE COURT: Then let's admit it now. Whose exhibit was it?

MR. WALL: Well, we were intending to use it. We ultimately thought this one was cleaner. But if there's no objection, I think we --

THE COURT: No. I'm referring to the map that had -- used by Dr. Hanson. It broke down the various areas of



the Delta where sampling in effect and measurements were taken. Where is that exhibit? Can you help us, Mr. Wilkinson?

MR. WILKINSON: I'll find it, Your Honor, if I may.

THE COURT: Thank you. That's it. All right. Does that have an exhibit tag on it, Mr. Wall?

MR. WILKINSON: Yes, Your Honor, it's State Water Contractors Exhibit H.

THE COURT: All right. If -- the color diagram is helpful, but just in terms of a locational reference, let's use the letter and number as close to the north Delta where you are arguing the delta smelt now exist.

MR. WALL: Your Honor, I believe Dr. Hanson, in his testimony, said that this past year the delta smelt spawned in the area of A4 on the Sacramento River.

THE COURT: All right. I agree.

MR. WALL: The southern part of the Delta, which would be in the area of perhaps A8 and A10 and A12, which contain critical habitat, is no longer regularly occupied by the delta smelt. Some of the smelt are entrained on their way in or out of that area.

And Dr. Moyle also testified that when the pumps in the Delta operated at high or moderate levels, they change the hydrodynamics of the Delta. They may confuse these fish as they try to swim into that area or be pulled off course into

less favorable environments.

Your Honor, and then there's the issue of entrainment, of course, which the defendants have principally focused and it is an important issue. We know that fish are being entrained at the project export facilities. We don't know how many. We know some are lost to predation before they're salvaged. We know some of them get pulled through the louvers at the fish screens. We know that the littlest smelt under 20 millimeters are not counted at all and no one has a precise idea of how many are lost.

What we do know is that this past summer, when the projects were allowed to operate without being subject to a court order, there were repeated days on which the projects counted not tens, but hundreds of delta smelt in salvage. And that was only the take of which we were aware.

Each of these adverse project impacts pushes the delta smelt a bit further towards extinction. Delta smelt is a species with no reserves, no spares, no back ups. And the projects are chipping away at its population. Most of these impacts are either not addressed by the defendants' proposed remedies at all or are addressed only partially.

Now, Your Honor, I won't reiterate the law. The Court is familiar with the NWF decision and the Court is familiar with the burden of proof. I will say this. In the face of uncertainty, the NWF decision, the Gifford Pinchot



decision, which has a similar ruling for criminal habitat, and the burden of proof require that uncertainty be resolved in the Delta smelt's favor.

Dr. Swanson has proposed ten remedial measures. And let me briefly review the evidence on those measures.

The first three involved monitoring. Continuation of existing monitoring or improvement of monitoring at the facilities, for example, that detect larval smelt. Larval monitoring at the project facilities is critical because we have no direct information at this time on when or how many larval smelt are being taken. They just aren't counted.

Better information about the presence and location of larval smelt is critical to effective operation of these projects, to avoid taking large numbers of delta smelt.

Defendants have raised no meaningful objections to this proposal. The agencies have contended that they might need to train some additional staff --

THE COURT: I believe they're also proposing that if we get to their remedies.

MR. WALL: I'm sorry, Your Honor?

THE COURT: I believe they're also proposing the monitoring if we get to their remedies.

MR. WALL: Your Honor, I believe the Fish & Wildlife Service does not. And I believe that Dr. Hanson's proposal, he mentions the possibility of exploring or developing



monitoring but he has no concrete proposal.

THE COURT: All right.

MR. WALL: If the agencies -- the contention they've raised is that they have to train some additional staff or perhaps buy some new equipment. If the agencies do not believe they're up to the task of training a few additional staff to conduct this monitoring, it's difficult to see how they could be entrusted with the more weighty work that they propose to be left to their discretion.

Dr. Swanson also proposes measures four through nine that are principally addressed at entrainment and improving the habitat of the southern part of the Delta as it's affected by the export operations.

Now, there's several of these about which there's no real contention. Dr. Swanson's action six is essentially -- it's just a continuation of the VAMP.

And actions eight and nine, which involve agricultural barriers, I don't believe any of the parties dispute those actions are a good idea as well.

So the focus of the contention here is on actions four and then actions five and seven. Much of the debate has been around the particular flow levels that Dr. Swanson proposed for her action four. And this is a measure that is timed to protect delta smelt adults before they spawn. These are the fish that have survived all the many causes of



mortality.

You recall that there is a very tiny percentage of the hatched fish that survive to reproduce. These are those fish. They are the mothers of the next generation, hopefully not the last generation of delta smelt. And it is critical that they be protected.

Dr. Swanson modeled her fourth protective measure, her action four, on a recommendation of the Delta Smelt Working Group, which is composed of the agency scientists. They proposed a range of flows and she chose the more conservative protective side of that range of flows, given the present status of the species that careful conservative approach is warranted.

Your Honor, Dr. Swanson's measures five and seven would essentially provide for Old and Middle River flows like those found during the VAMP period. But would begin those flows earlier and continue them later extending the period of protection that Dr. Bennett's work suggests VAMP provide.

Dr. Swanson took this approach because Dr. Bennett's work provides compelling, if new evidence that entire age classes of delta smelt, entire months of hatched fish are dying in mass.

Dr. Swanson also took this approach because, as she testified, she does not have confidence that the very statistical relationships between flow on the Old and Middle

1 River and take provide the necessary resolution to decide an
2 appropriate level of Old and Middle River flows, if there is
3 better information, such as that provided by Dr. Bennett.
4 These VAMP like flows would end once salvage ends.
5 And there's some dispute about what that end date would be.
6 Dr. Swanson is the only biologist who's addressed that point.
7 And she's testified that the fish would likely exit the system
8 sooner under the flow conditions she's proposed.
9 The testimony of the DWR witness looked at
10 a -- looked specifically at 1998, which was a very unusual
11 hydrological condition, where there was flooding throughout
12 the San Joaquin Valley that might have brought numerous delta
13 smelt into that area that would not normally be there.
14 And I respectfully submit, Your Honor, that is not a
15 typical condition and certainly is not the condition that Dr.
16 Swanson has specified in her proposed remedial action.
17 THE COURT: When she does say that salvage ends?
18 MR. WALL: June 15th or five days after the last date
19 of salvage. But she doesn't know the date when that will be,
20 but she says she expects, based on the response of these fish
21 to favorable conditions, that they would move out of the
22 system sooner than they have under higher export rates.
23 Dr. Swanson's tenth and final measure is designed to
24 protect delta smelt sub-adults during the fall. There's clear
25 peer reviewed persuasive evidence, both from the -- well, the



1 Feyrer work and also the work of the Delta Smelt Working
2 Group, and Dr. Moyle's research on the habitat needs of
3 rearing delta smelt that more fresh water outflow during the
4 fall will help push the low salinity zone down towards more
5 favorable habitat in Suisun Bay where it would be, but for
6 operation of the projects.
7 Defendants have argued that this measure is risky.
8 It is not risky. We know what habitat conditions are
9 beneficial to delta smelt. Creating habitat conditions that
10 are beneficial by moving the low salinity zone further
11 downstream may or may not prove sufficient to allow the
12 species to recover. But the trajectory of which this fish has
13 displayed in recent years at least indicates that providing
14 good habitat is a necessary condition for recovery.
15 Dr. Swanson's tenth measure is the only measure
16 proposed by any party to address this critical lifestage of
17 delta smelt. Now, this is a one-year species with high
18 mortality during the course of the year. We simply cannot
19 afford to ignore any lifestage nor may the projects' impacts
20 on that lifestage be ignored consistent with the Endangered
21 Species Act.
22 Your Honor, I'd like to briefly address the
23 defendants' and defendant intervenors' proposed remedies. And
24 I'd like to do that first by identifying some common
25 deficiencies in their proposals. The first is that these



1 remedies give the agencies extraordinary discretion at where
2 to set flow levels.
3 Ms. Goude's action four is a process. And though it
4 illustrates what might be done, it doesn't require anything
5 specific. It's effectively a new version of the DSRAM process
6 that this Court already held insufficient.
7 Similarly, Dr. Hanson's tier two remedy sets wide
8 sideboards between minus -- I believe it's minus 1,000 cfs and
9 minus 6,000 cfs for flow in the Old and Middle River. These
10 sideboards are so wide you could get lost in their waters.
11 Now -- he now says that the prudent thing to do would be to
12 operate at the protective end of that range. His proposal
13 does not require the agencies to do so. And in the past, the
14 agencies have not demonstrated a willingness to operate the
15 projects in a fully protective manner.
16 Dr. Hanson's third tier measure sounds strict. Once
17 you have substantial salvage, dramatic increase in salvage, I
18 think he says, then you curtail pumping operations at the
19 level necessary to protect the public health and safety. But
20 this only lasts four days and after that the agencies get to
21 consider what they're going to do.
22 Well, what happened this past summer? Once they
23 began increasing their pumping operations, we saw days after
24 days of high levels of take that continued for the better part
25 of the month.



1 A second flaw with the defendants' remedies is that
2 they rely on imperfect monitoring data. In many instances,
3 they are triggered by identification of delta smelt in the
4 vicinity of the project export facilities. The present
5 surveys and salvage measurements do not even count larval
6 smelt.
7 One of the surveys does look at larval smelt, but the
8 present abundance of larval smelt is so low that these surveys
9 are increasingly having difficulty detecting them even in
10 areas where they do exist.
11 The defense remedies are also deficient because they
12 don't look at protecting the fall lifestage of the species.
13 They're deficient because they, in the face of uncertainty,
14 err against more protective precautionary levels, which is
15 contrary to the requirements of the Endangered Species Act.
16 And finally, the defense experts were not willing to
17 testify that these remedies met the necessary legal standard.
18 This is really quite extraordinary.
19 Ms. Goude pointedly and repeatedly declined to offer
20 her opinion on whether the project's proposed operations would
21 cause jeopardy or avoid adverse modification. "I wouldn't
22 proffer an opinion on that," she said. I don't see how the
23 federal defendants can carry their burden of proof if their
24 expert won't testify that their project meets the legal
25 standard.

1 Dr. Hanson, for his part, asserted that his proposal
2 would be sufficient to prevent jeopardy or adverse
3 modification attributable to the project export facilities
4 depending on how they are operated. But he isn't saying that
5 if they operate at the less protective end of his range, they
6 would necessarily avoid jeopardy.
7 He also admitted that he had not even considered the
8 incremental contribution of any factor other than export
9 facilities. That apparently means in reaching a no jeopardy
10 decision or opinion, he did not consider the operations of the
11 remainder of these projects, the reservoirs that are
12 withholding outflow in the Delta in the fall.
13 Your Honor, I'm going to only say two things about
14 Dr. Miller's hypothesis. The first is that facts are
15 stubborn, but statistics are pliable. If I understood Dr.
16 Miller correctly, he has taken two variables, delta smelt at a
17 juvenile stage and food abundance, and put them into one
18 variable and related this to later delta smelt abundance.
19 This is a little bit like saying I'm going to try to
20 relate the co-occurrence of tomato plants and gardening gloves
21 with later tomatoes. Well, the fact that you get the tomatoes
22 later doesn't mean that they were caused by the gardening
23 gloves, they were caused by the tomato plants.
24 It's statistically invalid and it's consistent with
25 the findings of the peer review on his earlier conclusion,



1 which he proved through statistics just a few years ago that
2 delta smelt had recovered.
3 Your Honor, I'd like to briefly address the health
4 and safety and water supply issues. Plaintiffs propose an
5 explicit exception to their remedy to protect public health
6 and safety. There is a definition of public health and safety
7 in this context in federal law.
8 What this means is that under plaintiffs' proposal,
9 the defendants would not be required to take any action that
10 would impair the projects' ability to meet public health and
11 safety needs. This is a safety valve.
12 If the Court issues an order, it would have a safety
13 valve, an escape hatch, that if they need to do something else
14 to protect the public health and safety, they could do so.
15 This approach, under my understanding of the Court's
16 rulings about the evidence, makes the water cost information
17 presented to the Court irrelevant. Predicting the quantity of
18 water that would be needed to meet public health and safety
19 obligations in advance without information on the hydrology of
20 the coming year would probably be impossible and certainly be
21 unwise. Under our approach, the Court doesn't need to make
22 that prediction.
23 Beyond that, this Court has no warrant -- excuse me,
24 I'm losing my voice after several nights of no sleep. Get
25 some water. This Court has no warrant to consider costs



1 economic water or otherwise in deciding what remedy is
2 necessary to avoid increasing the Delta smelt's jeopardy or
3 adversely modifying its critical habitat.
4 This case is remarkably similar to TVA v Hill decided
5 by the Supreme Court, in the landmark and defining ESA
6 decision. In that case, also involved a federal water
7 project, it also involved a small uncharismatic fish.
8 The federal water project had cost something on the
9 order of 100 million dollars to build, which was a lot of
10 money back then. It was designed to provide electricity for
11 20,000 homes as well as flood control benefits, jobs and
12 recreational benefits. The Court said one might argue that
13 the burden on the public through the loss of millions of
14 unrecoverable dollars would greatly outweigh the loss of the
15 snail darter.
16 But neither the Endangered Species Act nor Article 3
17 of the constitution provide federal courts with the authority
18 to make such fine utilitarian calculations.
19 Congress viewed the value of the endangered species
20 as incalculable. Quite obviously, it would be difficult for a
21 court to balance the loss of a sum certain, even 100 million
22 dollars, against the Congressionally declared incalculable
23 value. Even assuming we had the power to engage in such a
24 weighing process, which we emphatically do not.
25 Your Honor, Congress has provided a process in



1 which -- by which the Section 7 obligations may be waived by
2 the executive branch to address public health and safety
3 emergencies or other problems of national and regional
4 significance.
5 Section 7 creates the endangered species committee
6 made up of high ranking executive branch officials in a
7 politically accountable branch of the government. And upon
8 proper application, this committee is empowered to exempt an
9 action agency from the requirements of Section 702 if doing so
10 is in the public interest.
11 The courts, however, are not empowered to do so.
12 Whether the delta smelt survives or falls finally over the
13 cliff of extinction, may well be decided in the next 12 to 18
14 months. Every biologist who has appeared before this Court
15 has reached that same conclusion. The science on what is
16 necessary to protect the delta smelt from falling over the
17 edge into extinction, let alone the science on what is
18 necessary to comply with the adverse modification requirement
19 is uncertain. We cannot look at a textbook, even Dr. Moyle 's
20 textbook, and be as confident as we would like that flows at
21 one level or another are protective while flows at another
22 level are not.
23 This uncertainty could make the Court's duty seem
24 difficult. This court's duty is not difficult, it is weighty,
25 but its duty is clear. The Court's duty is clear because we

stand in a courtroom, not in a legislative chamber. Congress has made a choice to preserve endangered species, whatever the cost. The judicial branch's duty is to enforce Congress' will. The agencies have failed to carry out their duty to prevent jeopardy and adverse modification. This Court must, however reluctantly, assume that responsibility. In doing so, the Court must, under controlling precedent, resolve uncertainties in favor of the delta smelt.

Your Honor, you asked about the issue of take limits and let me briefly address that. Our concern is protection of the delta smelt. We do not believe the present take limits are protected. On the other hand, invalidate -- or vacating the Biological Opinion doesn't put in place new take limits. And it may cause some take concerns for the agencies in operation of these projects.

We do not require vacatur of the Biological Opinion if the Court layers on top of it a protective remedy that ensures that these project operations will not deepen the jeopardy of the delta smelt or cause adverse modification of their critical habitat.

But the Court's order must accomplish those purposes. If the delta smelt loses its grasp, if the agency officials and defendant scientists who have guessed wrong in the past are guessing wrong again, if this Court's remedial order shaves the protections too closely, there will be no second



chance. One of the species placed on this earth, a species of little consequence to some, but incalculable value to Congress, will disappear forever.

Your Honor, the defendants have not carried their burden and this Court's duty is clear. We respectfully ask the Court to adopt the proposed remedies described by Dr. Swanson. Thank you.

THE COURT: Thank you, Mr. Wall.

MR. WALL: I'd be happy to answer any questions if you'd like.

THE COURT: I don't think we have time for questions. Mr. Maysonett.

MR. MAYSONETT: Your Honor, am I correct in understanding that I should try to limit my comments to 15 minutes? Is that where we are?

THE COURT: I'm going to leave it to both the defendants and the intervenors to divide the time as you see.

MR. WILKINSON: Yes.

MR. MAYSONETT: Thank you, Mr. Wilkinson.

THE COURT: So your colleagues will tell you. I will not.

MR. MAYSONETT: Your Honor, every scientist that has appeared before the Court has expressed serious concern over the current status of the delta smelt and the decline that it has experienced over the last four or five years. I'm not



going to dwell on those issues.

One question that I have heard the Court ask over and over again is what have the agencies that operate these projects been doing during that time to respond to the Delta smelt's decline? I'd lick to answer that question on behalf of the Bureau of Reclamation and the US Fish & Wildlife Service.

First, as the Court is aware, reclamation has consulted with Fish & Wildlife Service repeatedly under the Endangered Species Act on the effects of its operations on the delta smelt.

It's operated the projects in compliance with the Biological Opinion since 1995. It's implemented the Vernalis Adaptive Management Program and other measures to benefit of the delta smelt.

This summer, for example, as we heard Mr. Milligan testify, reclamation took extraordinary steps for the benefit of the delta smelt, limiting pumping down to one pump, which Mr. Milligan testified was minimum, from April 22 until June 12th. First as part of the VAMP, and then later under adaptive management.

Reclamation spent 5.2 million dollars to buy water to augment flows on the San Joaquin River for the benefit of the delta smelt.

As Mr. Milligan testified, as data came in showing



this decline of the delta smelt, reclamation reinitiated consultation of the service in 2006 before the Court had invalidated the most recent Biological Opinion.

Because it reinitiated consultation, reclamation also took steps under Section 7(d) of the Endangered Species Act. It has committed to not entering into any new long-term water service contracts until the new Biological Opinion is complete. It's halted progress on several major construction projects, including the Delta Mendota Canal, California Aqueduct Intertie. It's committed to maintaining pumping within recent historic levels.

Reclamation and the service also participate in the Pelagic Organism Decline group, which is sponsoring dozens of studies to investigate the cause of this decline comprehensively. And that the POD is -- which is the Pelagic Organism Decline -- is staffed and funded in large part by the Fish & Wildlife Service and Reclamation.

Now, in addition to those steps, Your Honor, the service has convened an interagency team of biologists to devise a matrix of actions that in the service's opinion will protect the delta smelt over the coming years. That proposal and its basis were described in Ms. Goude's declarations and her testimony.

As Ms. Goude testified, the service's proposal is based firmly in biology and was developed without the

consideration of potential economic impacts or reductions in exports. And importantly, the service has concluded that it will adequately protect the delta smelt over this interim period.

In many ways, the service's proposal is not entirely dissimilar from the suite of actions that the plaintiffs themselves have proposed. Throughout their proposal, however, the plaintiffs have generally, although not always, used more restrictive flow levels.

And they have included additional actions, including their action ten, the fall action, which would require certain minimum outflows from the Delta during the fall.

As a result, the plaintiffs' proposal will use significantly more water than the service's for benefits that the service concluded were marginal or uncertain.

Now, the plaintiffs have objected throughout these proceedings to any discussion of water costs. But I submit, Your Honor, that the Court not only can, but that it must consider the relative water costs of these proposals for interim relief.

And when I say "water costs," Your Honor, allow me to be clear. I'm not talking about the potential economic consequences of reduced exports, although those are considerable. I'm talking about the amount of water that would be required to implement the actions.



As Ms. Goude explained, the service and the Bureau of Reclamation cannot afford to look at project operations just over one year -- without considering how those operations will resound into the future. We have -- we are coming off a dry year on the Sacramento and a critically dry year on the San Joaquin. Storage at many reservoirs is below normal.

While there is disagreement over exactly how much each of the -- these proposals will cost, there is broad agreement that the plaintiffs' proposed action ten, the fall action, will by itself use about half a million acre feet of water.

So we know the plaintiffs proposed actions will use more water. Depending on conditions in the basin, that increased use of water could lead to low reservoir levels and if conditions remain dry, the effects of those operations could carry over through those reduced reservoir levels into next year.

In deciding how the projects are going to be operated over the next year, Your Honor, the Court cannot assume that we're going to have a wet year. The Court has to at least consider what will happen if we implement these actions and we are entering the second of a series of dry years. The Court has to consider the potential effects of a drought. And it has to consider those issues not just because of economic impacts, but because using water now may affect our ability to



meet the needs of listed species, including the Delta smelts and listed salmon in the future.

Your Honor, with introductory remarks done, I'd like to turn to the issue of remand and whether it should be with or without vacatur.

What I hear the Court saying, at least in its tentative ruling, is that it is considering remanding the Biological Opinion, of course it's going to remand the Biological Opinion, but doing so and vacating the Biological Opinion at the same time. And we have grave concerns over that result.

Because vacating the Biological Opinion will vacate the incidental take statement contained in that opinion and that incidental take statement shields reclamation and its employees from civil and criminal liability under the Endangered Species Act from take of delta smelt that occurs at the pumps.

THE COURT: What is the legal authority for the Court to leave in place an acknowledgedly insufficient scientifically inadequate take measure that does not offer the legally required protection of the species?

MR. MAYSONETT: Your Honor, I would say the cases we've identified in our briefs support the conclusion that vacatur can be without remand, where that --

THE COURT: Remand without vacatur.



MR. MAYSONETT: Is that -- the remand could be without vacatur.

THE COURT: You got it backward.

MR. MAYSONETT: Vacatur without remand, I'm not sure what that --

THE COURT: Nor am I.

MR. MAYSONETT: The remand could be without vacatur or it would result in serious disruption. And without an incidental take statement, we may have to shut the pumps down. We'll have to obviously evaluate the legal status there very carefully, but the pumps can't be operated with literally no risk of causing take. And we will have to look at that issue very, very carefully. We will have to operate the projects at our peril.

I think the plaintiffs are correct, what we should do is remand without vacatur, but then the Court should order whatever interim relief it believes is appropriate based on the evidentiary proceedings we've had to protect the delta smelt over the next year. In that way, we will both protect the delta smelt --

THE COURT: And they're willing to stipulate to that if the level of protect they seek is imposed. That's what Mr. Wall just said.

MR. MAYSONETT: Well, I understand that, Your Honor, of course we --

1 THE COURT: Did you hear him?
2 MR. MAYSONETT: I did hear him, Your Honor. And we
3 would accept that stipulation, of course, we take the position
4 that the level of protection that should be imposed is the
5 level of protection proposed by the service.
6 Let me turn briefly, Your Honor, to some of the
7 important distinctions between the proposals before you. And
8 I'm going to focus on the differences between the plaintiffs'
9 proposals and the service's.
10 One of the obvious ones is this action ten, the fall
11 action, which would require us to keep X2 at 80 kilometers or
12 minimum outflows of the 7500 cfs, whichever is less water.
13 The theory is that it will increase the quality of the habitat
14 for the delta smelt.
15 As I've already said, the measure has a very
16 significant water cost. It's likely to use -- it depends on
17 the water year, of course, but it's likely to use about a half
18 a million acre feet of water.
19 As Ms. Goude testified, the service considered
20 including this kind of requirement in its proposal, but
21 ultimately decided that the benefits were too uncertain and
22 the water cost too high.
23 And in reaching that conclusion, the service wasn't
24 alone. None of the groups that have considered this kind of
25 fall action have actually recommended it, or at least not



1 without significant reservations. When the Delta Smelt
2 Working Group looked at this --
3 THE COURT: You know, let me ask. It wasn't
4 presented -- at least if it was presented, it certainly was
5 referred to, I haven't had a chance to read it.
6 But the Bennett study, any recommendations that came
7 out of the Bennett study. I know it wasn't for this project,
8 but do the most recent peer-reviewed scientific analysis of
9 the status, does that study recommend or address fall remedial
10 action?
11 MR. MAYSONETT: My understanding, Your Honor, is that
12 the plaintiffs' action ten is not based on the Bennett study,
13 but rather on the Feyrer study, which is Plaintiffs' Exhibit
14 5. The Feyrer study cautions that the degree at which -- the
15 Feyrer study had that analysis of environmental quality for
16 the delta smelt. And they caution that the degree to which
17 their analysis could be used for management purposes remain
18 unclear.
19 And I'd like to point out that one of the co-authors
20 of that Feyrer study was, in fact, sitting on the Delta Smelt
21 Working Group when the Delta Smelt Working Group considered a
22 very similar fall action. This is in Plaintiffs' Exhibit 10.
23 And the Delta Smelt Working Group thought about it and decided
24 not to recommend because it concluded that it was not likely
25 to result in a significant increase in the amount of habitat



1 quality or quantity.
2 And the Delta Smelt Working Group also cautioned that
3 before we did any kind of fall action like this, it should be
4 set up as an experiment first so that we could test the
5 competing hypotheses about what effects it might have. And
6 that hasn't been done.
7 It's also worth noting that the California Department
8 of Fish & Game and the Department of Water Resources in their
9 Pelagic Fish Action Plan thought about a similar action that
10 would maintain X2.
11 Now, that action did go from May to December instead
12 of just September to December, so it was a much longer term.
13 But they describe the effects of that action as having a high
14 scientific uncertainty. And they caution that it should not
15 be undertaken in below normal years because then it would have
16 potentially dramatic effects on storage levels and temperature
17 conditions for fish upstream in the fall. And that's at State
18 Water Contractors Exhibit C at page 48.
19 So the benefits of the proposed fall action, Your
20 Honor, are uncertain. It's not clear that it will
21 significantly increase the quantity or quality of habitat
22 available to the smelt. And as Dr. Hanson testified and Dr.
23 Swanson acknowledged, it's unclear how the smelt will respond
24 to whatever increase in habitat quality or quantity occurs.
25 What is certain is that the fall action will use a



1 lot of water and, depending upon conditions in the basin,
2 using that water may have long-term effects. It may
3 ultimately impair our ability to provide flows for the delta
4 smelt and for listed endangered salmon species in future
5 years.
6 For those reasons, Your Honor, we think the service
7 was right to reject it.
8 Turning briefly to monitoring, Your Honor, the
9 plaintiffs have proposed several monitoring actions. The
10 third, action three, would propose a new monitoring program
11 for sub-20 millimeter delta smelt. You had a brief colloquy
12 with counsel about that. We don't think that's appropriate.
13 I'm not sure that's clear.
14 We think that it suffers from important legal
15 scientific and simply practical problems. Legally, we don't
16 think there's a basis in the Endangered Species Act to order
17 an agency to conduct new monitoring. We believe that the
18 Endangered Species Act requires agencies to rely on the best
19 scientific and commercial data available. That's the standard
20 of the statute.
21 The statute doesn't allow the service to wait for
22 more better data to be developed and we think that the relief
23 here should be found on the same standards.
24 Significantly, I'm not aware of any case where a
25 Court ordered, under the Endangered Species Act claim, some

1 agency to conduct new monitoring.
2 We think there are scientific reasons to be skeptical
3 about the value of this data as both Dr. Swanson and Ms. Goude
4 explained. One of the reasons we have such valuable data on
5 the delta smelt is that so much of these surveys and so many
6 of this monitoring has been conducted for a long period.
7 And finally, there are practical problems, Your
8 Honor, in the sense that we wouldn't just have to hire new
9 staff, but it will take time. Telling two five-millimeter
10 fish larvae apart is very difficult. And the time it takes to
11 identify those larvae may create backlogs, it could jeopardize
12 our ability to create the real time salvage data that we have
13 been able to provide in previous years.
14 I think I'm going over my time here, Your Honor. I'm
15 getting that look from my co -- or the other counsel. So let
16 me just wrap up and say that in conclusion, Your Honor, the
17 service has developed a matrix of proposed actions that we
18 believe will protect the delta smelt over the next year. We
19 think it's supported by the science, that it's appropriately
20 flexible, give the operators the flexibility they need to both
21 protect the smelt and respond to conditions on the ground.
22 And that it makes the best use of water that we have, which is
23 important not just for other reasons, but because it will help
24 us in future years with smelt and other listed species. And
25 for that reason, it is narrowly tailored and it is the



1 appropriate injunctive relief.
2 THE COURT: And as I understand it, your position is,
3 for the federal defendants, remand without vacatur
4 implementing the protective conditions that are proposed in
5 the five point action matrix?
6 MR. MAYSONETT: Yes, Your Honor. That's correct.
7 That's what we advocate.
8 THE COURT: Thank you. Mr. Lee for the state.
9 MR. LEE: Your Honor, I just want to begin to say I
10 support that position of federal government. And I just want
11 to get that out of the way so we can go into the basis of the
12 statement.
13 Your Honor, all parties before this Court recognize
14 that the delta smelt are in a state of significant decline.
15 The California Department of Water Resources does not doubt
16 that this Court has repeatedly stated that business as usual
17 is not an option for the delta smelt or for the California
18 State Water Project.
19 At this end, the Department of Water Resources
20 embraced with two minor modifications the delta smelt action
21 matrix for water year 2008 prepared by the US Fish & Wildlife
22 Service and attached to the July 3rd, 2007 declaration of Cay
23 Goude. The Department of Water Resources takes this step
24 fully aware of the water supply consequences of this decision.
25 As the testimony of John Leahigh has disclosed,



1 adoption of a modified US Fish & Wildlife Service proposal
2 could cost the communities of this state that rely on Central
3 Valley Project and State Water Project water, as much as 1.4
4 acre feet of water in an average year and as much as 415,000
5 acre feet of water in a dry year.
6 Nonetheless the Department of Water Resources
7 recognizes that protection of the delta smelt at this time in
8 this proceeding is a first order priority for the state.
9 THE COURT: Let me ask one more question of Mr.
10 Maysonett because you reminded me of it.
11 MR. MAYSONETT: Yes, Your Honor.
12 THE COURT: Do you accept or reject the proposed
13 modification that Mr. Leahigh discussed this morning?
14 MR. WILKINSON: Negative 300 cfs instead of zero.
15 MR. MAYSONETT: It's not part of the service's
16 proposal, Your Honor, I think it's something that we would
17 have to evaluate. I don't know if the service has had a
18 chance to review it.
19 THE COURT: Between now and five p.m., I suggest that
20 you evaluate and have the Court an answer.
21 MR. MAYSONETT: Thank you, Your Honor. I'll get
22 right on that.
23 MR. LEE: Hopefully that came out of the federal
24 government's time, Your Honor.
25 THE COURT: Thank you, Mr. Lee, as always.



1 MR. LEE: In sorting out the appropriate protective
2 measures, I would like to focus on three categories of smelt
3 protection relating to three lifestages that were addressed by
4 the testimony before this Court.
5 One, what new measures are necessary to protect
6 pre-spawning adult smelt during that late winter period.
7 Two. What measures are necessary to protect juvenile
8 and larval smelt in the winter through spring period.
9 And three, is the plaintiffs' fall action designed to
10 impose the salinity level in the western Delta justified based
11 upon evidence that is before this Court.
12 Let's go straight to that first issue, Your Honor.
13 The protection of pre-spawning adults during the winter and
14 early spring period. As the testimony shows, beginning
15 roughly in December, adult delta smelt began to move upstream
16 from the confluence of the San Joaquin River and Sacramento
17 River into the Delta.
18 The Department of Water Resources supports two
19 actions to protect the smelt during this important lifestage.
20 First, the Department of Water Resources supports the
21 US Fish & Wildlife action number one. This action would
22 commence on or after December 25th or upon the occurrence of
23 certain turbidity events. For a ten-day period, negative
24 flows at Old and Middle River could not exceed negative 2,000
25 cubic feet per second.

Now, in reviewing the testimony over the last six days, the primary dispute as to this action appears to be the competing proposal of the plaintiffs in their action four. The plaintiffs' action four proposes a zero negative flow value for this period.

However, Ms. Cay Goude of the US Fish & Wildlife Service testified that based upon the advice of her biologists, biologist colleagues at the US Fish & Wildlife Service, quote, negative 2,000 cfs would be sufficient for this period." And that can be found in her August 23rd testimony on pages 161 through 162.

This position is also reinforced by the testimony today of Mr. John Leahigh, who indicated the very practical problems given tidal and atmospheric conditions and other diversions of meeting a zero flow requirement. DWR is not aware of any contrary testimony directly disputing the adequacy of the negative 2000 cfs value in action one and we would therefore urge the Court to adopt this measure.

The second part of action one involves a separate kind of action. DWR endorses this modified version characterized -- I'm sorry -- in US Fish & Wildlife Service action number two. The US Fish & Wildlife Service recommends that upon onset of spawning, that the daily net upstream flow of old Middle River not exceed negative 4,500 cfs for a 14-day running average and a negative 5,000 cfs for a seven-day



running average.

The Department of Water Resources would recommend modifying this measure, and this is one of the two modest modifications, to negative 5,500 cfs for a 14-day running average, and negative 6,000 cfs for a seven-day running average at Old and Middle River.

Now, what is the scientific basis for this? Because that is -- in the end is where we are at. The Department of Water Resources bases its modification after reviewing the only scientific data presented to this Court on statistical relationship between project salvage of smelt and the Old and Middle River flows.

One, the graph prepared by Dr. Pete Smith contained in Figure 8 of the July 23rd 2007 declaration of Dr. Swanson, that would be Plaintiffs' Exhibit 11. And 2, Exhibits B and C attached to the July 9th, 2007 declaration of Jerry Johns, DWR Exhibit G.

Let's go to the Pete Smith declaration. Excuse me. The Pete Smith figure. As both plaintiffs' experts Dr. Moyle and Dr. Swanson have affirmed in their testimony, Dr. Smith's -- Dr. Smith's graph contains altered data points. This concession can be found on Dr. Moyle's testimony on August 21st at page 119 and Dr. Swanson's testimony on August 23rd.

Dr. Moyle testified that the practice of altering



data and preparing a regression analysis was not consistent with acceptable scientific practice. And that it was his estimate that the R-squared value would decline if erroneous data points were removed. That again can be found in Dr. Moyle's August 21st testimony.

Moreover, Dr. Swanson testified that she was aware that Mr. -- that Dr. Smith's graph contained altered data before she prepared and submitted her declarations to this Court. But explained -- but failed to explain that fact to this Court in her declarations.

Given these circumstances, the Department of Water Resources submits that this Court should not -- should not give any weight or very little weight to Dr. Smith's regression analysis. The submittal of an analysis based upon altered, dare we say falsified data, even for a noble purpose, should not be encouraged by this Court.

Now, to the contrary, the graphs contained in Exhibits B and C of Jerry Johns' July 2007 declaration do not contain any altered data points. That can be found at DWR Exhibit G. A review of these graphs disclosed that for the months of January and February, smelt take significantly increases at the point where Old and Middle River flows exceed negative 6,000 cfs. Plaintiffs contend that splitting data between January and February somehow, quote, "distorts," end of quote, the information.



However, when forced to move beyond the hypothetical and to consider the actual real world data displayed in the graphs, the plaintiffs have not been able to point to any real world data example of how splitting the data between the two months had any policy consequences for recommended negative flows in Old and Middle River. Exhibits B and C to Jerry Johns July declaration therefore represents the best available science regarding the relationship between project salvage and Old and Middle River flows.

In summary, the testimony before the Court supports the US Fish & Wildlife Service action number one and supports action number two as modified by Exhibits B and C to the Johns declaration.

If I can move on now to the second lifestage that I'd like to talk about, which is the protection of juvenile and larval smelt during the winter through spring. Here, Your Honor, we have two clear choices. Do you want to rely upon the US Fish & Wildlife Service as they have proposed in their actions three and four of their matrix to assess real time data from sources such as temperature data, Kodiak Trawl Surveys, Particle Tracking Models, salvage data and the 20 millimeter survey, and to make flow decisions within a designated range of flows based upon this data or do you want to adopt the plaintiffs' inflexible flow requirements that would mandate specific flows regardless of what the real time

data would tell you. These are the two choices that the plaintiffs and the defendants have presented with regard to their competing remedy proposals.

Now, plaintiffs have objected to the US Fish & Wildlife Service's actions three and four on the grounds they are triggered by allegedly unreliable monitoring data. So I would urge the Court to go back and look at the testimony, both of Dr. Moyle and Dr. Swanson. They contend that the unreliability derives from the unreliability of the 20 millimeter survey and that it does not adequately detect larval smelt.

Let us assume that's true, Your Honor. The review of Attachment A to the US Fish & Wildlife Service matrix discloses that the matrix relies on multiple sources for real time data. Not just the 20 millimeter survey. And that would be DWR Exhibit A.

Both Dr. Moyle and Dr. Swanson testified that temperature data and the Kodiak survey data provided reliable information regarding spawning adult smelt and therefore provided a reliable predictor of the likely presence of smelt larvae one to two weeks later. This can be found in the August 21st testimony of Dr. Moyle and the August 22nd testimony of Dr. Swanson.

So notwithstanding the plaintiffs' assertion, reliable tools for detecting larval smelt do exist and have



been applied.

However, Your Honor, there's a bigger dispute here than a simple quibble over the efficacy of monitoring. The heart of the plaintiffs' objection to the US Fish & Wildlife Service's action three and four is the plaintiffs simply believe that the US Fish & Wildlife Service cannot and should not be trusted to choose among the range of flows for this time period based upon sound biological science.

Now, if this Court believes that the US Fish & Wildlife Service cannot be trusted to make these judgments, then I cannot see any other conclusion than having the Court side with the plaintiffs and reject actions three and four.

THE COURT: Well, let's look at the evidence and you can respond to this. I specifically asked questions of the operator, at least the federal operator, for that very purpose. Because in light of conditions that caused the experts who had been constituted under the Biological Opinion DSRAM to do exactly that, they made recommendations. Those recommendations were certainly considered. They were neither implemented nor followed. So in terms trusting the agency, that's exactly what that speaks to.

MR. LEE: Your Honor, may I respond directly to that?

THE COURT: That's what I'm asking you to do.

MR. LEE: I think that rather proves or supports the point that I'm trying to make rather than contradict it. The



profound and dividing distinction between the DSRAM that was in the 2005 Biological Opinion and the US Fish & Wildlife Service matrix presented is as Ms. Goude said, the service in the matrix makes the final call. That was never clear from the DSRAM process and it is clear certainly to the Department of Water Resources' position that the final call for measures that are adapted in the matrix will be made not by a collective group such as the WOMT, not by service heads, but by -- not by agency heads, but by the service and the service alone.

I might say this is sort of difficult for a lawyer for the State of California to say in a federal court, but in this situation, we agree that the federal agency, the US Fish & Wildlife Service is where the buck stops. And that is a material difference from the DSRAM process, Your Honor.

Now, to the contrary, the plaintiffs' flow regime for this time period are based upon what we would submit is uncertain science. The plaintiffs have grounded their flow recommendations for this time period on the 2006 PowerPoint of Dr. William Bennett. The presentation that has been colorfully called the Big Mama theory.

However, Dr. Moyle, in his own testimony, repeatedly characterized the Bennett presentation not as settled scientific consensus view, but as a, quote, "hypothesis," end of quote.



As noted by most of the testimony, Dr. Bennett's hypothesis has not yet been reduced to writing and it appears, from the testimony of Dr. Miller, that Dr. Bennett has not been willing to even share the PowerPoint presentation or its underlying data with others. We submit that this is a very slender reed to support a fish action that may cost the projects hundreds of thousands of acre feet solely based upon a preliminary hypothesis.

With one minor modification, the Department of Water Resources supports the US Fish & Wildlife Service action. As has been noted earlier, the action has a zero to negative 4,000 cfs range.

Based upon the testimony of John Leahigh, which we heard this morning, the Department of Water Resources would submit that hydrologic justification submits for upping the low end from zero to negative 1500. But in all other respects, the Department of Water Resources supports that measure.

THE COURT: And leave the upper end at negative 4,000?

MR. LEE: Yes, Your Honor. Last point, Your Honor. The fall measures for habitat protection. I first wanted to put aside a straw --

THE COURT: This is number ten.

MR. LEE: Yes, this is fall action number ten, Your

1 Honor. First of all, I want to put aside a straw man argument
2 raised by plaintiffs, which is that the claim that -- the
3 matrix by the US Fish & Wildlife Service does nothing for
4 smelt habitat. We can argue repeatedly what the matrix says,
5 but we would ask the Court to look at the testimony of Dr.
6 Moyle on August 21st, 2007 on page 108 of the transcripts.
7 "Question: If the projects were, in fact, to reduce
8 pumping and minimize or reduce the amount of negative
9 flow in the San Joaquin or Old and Middle Rivers,
10 would that have a beneficial effect on the smelt's
11 habitat in the south Delta?
12 "Answer: Yes. I think it would."
13 So the issue is not whether the plaintiffs' proposal
14 addresses habitat issues and the US Fish & Wildlife proposal
15 ignores them, the issue is which habitat measures are
16 supported by the best available science. DWR would submit
17 that the best available science is -- does not justify the
18 fall action suggested by the plaintiffs.
19 I want to move quickly through this, simply to
20 comments related to Feyrer paper, which appears to be the only
21 source of data that has not been established to be
22 statistically insignificant. The Feyrer article should be
23 read alongside the recommendation for the Delta Smelt Working
24 Group, who have considered this issue on numerous occasions.
25 On page 732 of the Feyrer article, this will be



1 Plaintiffs' Exhibit 5, the authors conclude, quote, "The
2 degree to which EQ could be used for management purposes
3 remains unclear."
4 In its August 21st, 2006 delta smelt meeting notes,
5 the delta smelt group addressed the fall X2 issue and
6 concluded, quote, "It did not recommend it because 7,000 cubic
7 feet per second is not enough flow to detectably change
8 physical habitat quantity and quality for the delta smelt."
9 That's Plaintiffs' Exhibit Number 10.
10 On page 732 of the Feyrer piece, the article states,
11 "For the water quality" -- "that for the water quality data to
12 be most effect tough for species management, additional
13 information is needed." End of quote.
14 The delta smelt Working Group's August 21, 2006
15 meeting notes similarly state that there is need for further
16 experimentation to test this hypothesis.
17 Thus the two non-advocacy biological experts who have
18 offered opinions in this case agree that there is no need for
19 fall salinity action today and there is need for additional
20 study. This is not surprising since the authors of the delta
21 smelt -- of the Feyrer paper and the members of the Delta
22 Smelt Working Group overlap.
23 In conclusion, DWR would recommend that the interim
24 remedy, the US Fish & Wildlife Service matrix with the
25 modifications be adopted. It is the intent of the Department



1 of Water Resources to follow such a modified matrix as a first
2 order of protection for the smelt. Where consistent with this
3 matrix, the Department of Water Resources would otherwise
4 continue to operate the State Water Project as described in
5 the 2005 BiOp, including the continuation of the EWA.
6 We are now very close to the end of a very long
7 period for all of us. We ask this Court to adopt a remedy
8 that we think is both -- that we think is protective, that we
9 think is feasible and that we think is fair. That remedy, we
10 submit, is the modified US Fish & Wildlife Service matrix as
11 we've described it.
12 THE COURT: Thank you, Mr. Lee. We're going to do
13 one more before we break.
14 MR. WILKINSON: Thank you, Your Honor.
15 THE COURT: Mr. Wilkinson.
16 MR. WILKINSON: Your Honor, I'm going to dispense
17 with the preliminaries. I don't think you need them and I
18 don't have the time. I'm going to start by going through the
19 actions in the order in which they would take effect. I'd
20 like to give you then our comments on those as they would
21 occur.
22 THE COURT: Well, just tell me where -- the
23 fundamental position the State Water Contractors have. Tell
24 me where you are.
25 MR. WILKINSON: Our fundamental position is that Dr.



1 Hanson's tier one, tier two and tier three measures are the
2 ones we believe the Court should impose.
3 I'm going to start, though, with Dr. Swanson's action
4 ten, which is proposed to begin tomorrow. We believe the
5 evidence is insufficient to support that measure. No one,
6 including Dr. Swanson or Dr. Moyle, could tell us whether or
7 by how much smelt abundance could increase if that measure was
8 implemented. And there has been absolutely no demonstration
9 that this action is needed.
10 Instead, the evidence is uncontradicted that the
11 state project and federal project are already meeting water
12 quality objectives that will provide suitable salinities for
13 the smelt and particularly for the sub-adult delta smelt and
14 will continue to do so through the fall. Those salinities,
15 Your Honor, that will result at Kilometer 80 are well within
16 the salinity tolerance of the species.
17 Now, as Mr. Maysonett mentioned, Dr. Swanson's action
18 would require about half a million acre feet of water to
19 implement. Because of that, we think it's important to ask
20 what is it based on. The answer is it is based on a single
21 article whose authors have already indicated that the extent
22 to which their work can support management actions is unclear,
23 that there is no statistically significant relationship
24 between their EQ measure and smelt abundance at Kilometer 80
25 and that more information is needed to understand the

1 mechanisms that may underlie an EQ abundance relationship.
2 And as was mentioned by Mr. Lee, two of the authors
3 of that article sit on the Delta Smelt Working Group, Mr.
4 Nobriga and Mr. Sommer. And when that group considered a fall
5 action, Mr. Nobriga was on the group and the group declined to
6 recommend the action.
7 They did so because they concluded that releasing a
8 rate of water, about 70,000 cfs, very similar to that proposed
9 by Dr. Swanson, would not be sufficient to make any detectable
10 change in physical habitat quality or quantity. And also that
11 it would not likely change the distribution of the overbite
12 clam and the -- I guess it's the underbite clam, the fresh
13 water clam.
14 And it's -- as I think Mr. Maysonett mentioned, the
15 Pelagic Fish Action Plan was another indication, another
16 instance where the fall action measure was not recommended.
17 Simply put, we believe that Dr. Swanson's action
18 number ten is built on insufficient science, is supported by
19 no one other than Dr. Swanson and would impose enormous water
20 supply costs to achieve unknown impacts on smelt abundance.
21 It should not, we believe, be part of any remedy that the
22 Court imposes.
23 Now, the next action that would come up in
24 chronological order would be Dr. Hanson's tier one measure.
25 This action would commence on December 1 of this year. That's



1 almost a month earlier than Dr. Swanson's action number four
2 and a month earlier than the Fish & Wildlife Service's action
3 matrix.
4 Dr. Hanson's tier one measure is intended to maintain
5 a positive net westerly flow in the lower San Joaquin River in
6 order to push young smelt out of the influence of the projects
7 and prevent the intrusion of turbidity.
8 And Your Honor, it is costly. According to Mr.
9 Leahigh's testimony this morning, it would require about
10 300,000 acre feet to implement if 2007 or 2008 are dry or
11 average. It is not by any means or any stretch of the
12 imagination business as usual. And it would not put the smelt
13 at risk at all. There is no down side for the species by
14 implementing Dr. Hanson's tier one measure.
15 The up side for those who rely on the projects, and
16 the reason we are willing to bet almost 300,000 acre feet of
17 water on it, is that we believe it will work and it will avoid
18 the need for more restrictive measures to be implemented in
19 the winter and spring. And Your Honor, if it doesn't work, we
20 have Dr. Hanson's tier two measure, a modification of the Fish
21 & Wildlife Service's matrix to rely on.
22 Now, the next actions chronologically that would come
23 up as the calendar proceeds would be Dr. Swanson's action
24 number four and the Fish & Wildlife Service's action number
25 two. Both actions would commence about Christmas Day.



1 Dr. Swanson's action four would require the
2 management of Old and Middle River flows to achieve a target
3 negative 3500 cubic feet per second from about Christmas Day
4 to the end of February or the onset of spawning. The only
5 science cited by Dr. Swanson to support her measure number
6 four is the Pete Smith graph that attempted to plot delta
7 smelt salvage against reverse flows in Old and Middle River.
8 But we do know that Dr. Smith altered the data in his
9 graph. We also know that Dr. Smith has now decided that his
10 graph is not final, it is, quote, "preliminary" and, quote,
11 "subject to modification."
12 In addition, Your Honor, we know that Sheila Greene
13 of the Department of Water Resources reanalyzed the same data
14 that was used by Dr. Smith and found that the salvage of
15 pre-spawning delta smelt shows no significant increase below
16 Old and Middle River flows of negative 6,000 cfs.
17 Now, the difference in allowing Old and Middle River
18 flows of negative 6,000 cfs instead of negative 3500 cfs is
19 enormous in terms of the water supply impacts. It is 5,000
20 acre feet of water per day or 150,000 acre feet per month or
21 300,000 acre feet over the two month period that Dr. Swanson's
22 action number four is proposed to be in effect.
23 Now, not only does Dr. Hanson's tier two measure and
24 action number three of the Fish & Wildlife Service matrix
25 offer more flexibility in adjusting project operations to real



1 time circumstances, they are more protective than Dr.
2 Swanson's actions since they allow for lower as well as higher
3 Old and Middle River flows if the circumstances warrant.
4 Now, we do have concerns, however, with the action
5 number three in the Fish & Wildlife Service matrix and I think
6 Your Honor has identified those. The low end of the Fish &
7 Wildlife Service range of Old and Middle River flows is zero.
8 This --
9 THE COURT: Or negative 15 --
10 MR. WILKINSON: No, it's zero. The negative 1500 is
11 the DWR modification.
12 THE COURT: Modification. That's right.
13 MR. WILKINSON: Correct. That's right. We believe
14 that modification is appropriate. Certainly the Fish &
15 Wildlife Service action number three is more protective than
16 Dr. Swanson's negative 3500, but we believe it's too low.
17 THE COURT: Let me ask you a legal question.
18 MR. WILKINSON: Yes, sir.
19 THE COURT: We've had strenuous objection from San
20 Luis and Delta Mendota and Westlands to the Court's authority
21 to do anything immediate. In effect what they say legally is
22 that the Court has no jurisdiction to tell the agency to do
23 anything. What's your legal position?
24 MR. WILKINSON: What is my position on that?
25 THE COURT: Yes. The State Water Contractors. What

is the legal position of the State Water Contractors?

MR. WILKINSON: Your Honor, we have not taken the position that the Court has no authority. We do believe that the Court needs to narrowly tailor any release that it does grant. We believe that the Court, if it is presented with multiple remedies, each of which would prevent jeopardy and avoid adverse modification, that the Court not only may, but should and is obligated to choose the measure which is the least damaging. And here we think that is the case with regard to this question about zero or negative 1500 cfs.

As Mr. Milligan testified when Your Honor questioned him, it would be extremely difficult for the projects to meet that flow. Because even if they completely shut down, there are others within Old and Middle River who divert. And those diversions cause reverse flows.

So by requiring projects to mitigate those reverse flows, to bring them down to zero, the service's matrix in effect is obligating the projects to make up for the impacts caused by those who are not project water users. We think that's not only unfair, but it's probably illegal. We don't think that authority extends that far.

So we believe that both Dr. Hanson's tier two measure and the modification of the matrix proposed by the Department of Water Resources is highly appropriate in these circumstances because it would tailor the remedy to the damage



caused by the projects in terms of reverse flows.

THE COURT: Is the answer to my question that if the agencies consent, then the authority exists?

MR. WILKINSON: I think I could support that view.

THE COURT: You may proceed.

MR. WILKINSON: I want to talk next, Your Honor, about Dr. Swanson's actions five, six and seven. These actions are intended to mimic the low end of the VAMP export rates. In their entirety, they are based upon work by Dr. Bennett that is unpublished, that has not been peer reviewed and that is not publically available. There is not a single party to these proceedings who has been able to see anything other than the PowerPoint presentation mentioned by Mr. Lee. Dr. Bennett has issued no paper. He has not made his underlying data available to anyone.

To impose that measure, those measures based upon that underpinning, we believe would be not only inconsistent with the principles of scientific method, but would be incompatible with the legal requirements of the Endangered Species Act itself. This is not science that is available as the Act requires. And this is a significant matter.

Those actions five, six and seven that have been proposed by Dr. Swanson would target flows at Old and Middle River at negative 1500 cfs for the entire period of time from February through early to mid July. It's a long period of



time.

Now, by contrast, the Fish & Wildlife Service matrix would manage flows during that period to a range from zero to 4,000, negative 4,000 cfs. If the flows are at negative 4,000 cfs, the difference between Dr. Swanson's measures, based upon this Bennett unpublished work versus the matrix could be up to 5,000 acre feet a day. Again, that would be 150,000 acre feet a month or about 300,000 acre feet over the period that Dr. Swanson proposes to implement her measures.

THE COURT: And doesn't DWR want these modified as well, these flows?

MR. WILKINSON: DWR is content, I believe -- and Mr. Lee correct me -- to go with the zero to 4,000. We believe, during this period of time, that the flows should be negative 1,000 to negative 6,000 cfs. And Mr. Lee, am I correct about that, in terms of the department's position?

MR. LEE: Are you talking about -- excuse me, are you talking about action three?

MR. WILKINSON: Yes, it's over the period of time.

THE COURT: No, we're in five, six and seven now.

MR. WILKINSON: Swanson's five, six and seven, states --

MR. LEE: As I understand it, Swanson's five, six and seven are in the same time period as three and four. We -- the range here would be consistent with your



understanding, which would be negative 1500 cfs to 4,000.

MR. WILKINSON: Thank you.

MR. LEE: That would be our modest modification to this particular element of the matrix.

MR. WILKINSON: Our modifications over that period, Your Honor, are about the same on the low end, they go a little higher on the upper end to negative 6,000. As the testimony indicated, that modification would be based on the work of Sheila Greene. That was the sort of L shaped curve that you saw in a couple of graphs that indicated the uptake --

THE COURT: That is the zone of danger, negative 6,000 --

MR. WILKINSON: 6,000. Right. And so we believe that the upper end of that range should not be 4,000, but should be 6,000 based on the work done by Ms. Greene.

Now, the next action that would take effect potentially would be Dr. Hanson's tier three measure. This is the only proposal before the Court, the only one, that provides for an immediate curtailment of project operations in the event that project pumps are found to be taking a significant number of delta smelt. This proposal would shut down the project pumps in that event and would give the agencies the time to decide what should be done to further protect the smelt.

THE COURT: We can't, as we learned in June, have a complete shut down because that disables the pumps.

MR. WILKINSON: It could potentially do that.

THE COURT: At least disables the federal system's pumps.

MR. WILKINSON: It could potentially do that. And Dr. Hanson's measure, I think the question was asked yesterday, are there triggers for that action. There are triggers, Dr. Hanson testified that he would rely on the Kodiak trawl, the fall midwater trawl data and the Particle Tracking Model to implement that tier three measure.

So in that sense, our proposal goes beyond those of any of the other parties. We think it may be appropriate -- we would be content, frankly, Your Honor with the Fish & Wildlife Service action matrix if the lower end of that zero to 4,000 range was increased to negative 1500 and if the upper end of the range was increased to negative 6,000 to correspond with the data from Sheila Greene.

To conclude, Your Honor, all of the proposals that you have heard are going to prevent jeopardy to the delta smelt and will prevent adverse modification to the critical habitat. Dr. Swanson's proposal, we believe, is enormously consumptive of water resources. The testimony this morning was that it could take up to 60 percent of the combined yield of both projects. And we think it largely ignores real time



data and that that is inappropriate in the circumstances facing the smelt.

These real time data around which the matrix is constructed of the Fish & Wildlife Service, the modified matrix of DWR and our proposal are the best available science. And they are integral to both those matrices and ours.

Because Dr. Hanson's modifications are the most narrowly tailored remedy, we believe, we think that remedy should be the one that you adopt.

THE COURT: Thank you, Mr. Wilkinson.

MR. WILKINSON: Thank you, Your Honor.

THE COURT: Now, what, Mr. O'Hanlon, Mr. Buckley, what are you going to do with regard to your arguments?

MR. O'HANLON: Your Honor, I have a few comments. I have significantly reduced the scope of my comments in response to the Court's direction, but I would like to make --

THE COURT: I haven't directed you to reduce them at all. I've only asked questions so that the questions could be addressed. I didn't in any way suggest that you attenuate or limit the arguments you will present.

MR. O'HANLON: I understand, Your Honor. I didn't mean to say direction. I meant to say Court's comments. I changed the focus of my comments in response to the Court's comments.



THE COURT: And can you address the issues I've raised about your client's positions in the litigation?

MR. O'HANLON: Yes, Your Honor, I can address issues that the Court has indicated are still relevant. In terms of a remedy proposal, I don't have an alternative remedy proposal to make and we do not endorse any of the remedy proposals made by the other parties.

THE COURT: Understood. Mr. Buckley, what's your --

MR. BUCKLEY: Yes, Your Honor, I think as you know, I sat quietly through most of the proceedings here.

THE COURT: Yes, you have.

MR. BUCKLEY: I would like to make a closing argument of approximately six or seven minutes. We do have a position with respect to the remedy proposals. We will, in a qualified way, endorse one of them. I would like to address some of the comments plaintiffs have made about the cause of this problem, which I don't think, on behalf of my client, I can leave unanswered.

THE COURT: All right.

MR. BUCKLEY: I but I don't think it will take more than six or seven minutes.

THE COURT: Thank you. Mr. Wall, are you planning on making a rebuttal?

MR. WALL: Your Honor, there are a few specific factual assertions have been made that I do feel I need to



respond to.

THE COURT: Can you do it in five minutes?

MR. WALL: I will -- I'll tailor it to five minutes.

THE COURT: Thank you. All right. Let's stand in recess until 15 minutes before five.

(Recess.)

THE COURT: Please be seated, ladies and gentlemen. We're going to proceed with closing arguments. Mr. O'Hanlon. You may proceed.

MR. O'HANLON: Thank you, Your Honor. We respectfully disagree with the Court's decision to impose an order against project operations. The Court has indicated that it found the evidence does not preponderate in our favor. I will not try to further argue that evidence now.

The Court has explained that it will consider the impacts of the remedy for limited purposes. I will address that. I cannot overstate the seriousness of the impacts that these proposals would impose. The farmers in the CVP service area south of the Delta are already perpetually short of water. These impacts would be on top of those impacts. They will feel these measures directly and acutely. In a sense, they are in peril too.

Now, Mr. Leahigh calculated the combined export reductions for the CVP and the SWP. We submitted the declaration of James Snow, two declarations, that translate

1 those delivery reductions for the CVP into the delivery
2 reductions for CVP contractors taking into account two
3 factors. One, the application the CVPIA Section 3406(b)(2)
4 and, two, the differing priorities among CVP contractors.
5 Mr. Snow, in his declaration, calculated the delivery
6 reductions as follows: For ag service contractors south of
7 the Delta, in an average year, their current base supply is 55
8 percent contract entitlement. Under the plaintiffs' proposal,
9 they will receive a zero allocation. In a dry year, their
10 base allocation is 30 percent. Under the plaintiffs'
11 proposal, they again will receive zero allocation. No water
12 under the plaintiffs' proposal.
13 The US Fish & Wildlife Service matrix actions are a
14 bit better, but still very severe. Instead of a base supply
15 of 55 percent in an average year, their deliveries will be
16 reduced to 20 to 40 percent. In a dry year, under the Fish &
17 Wildlife proposal, deliveries would be reduced to five to 25
18 percent of the contract entitlement.
19 Under the DWR revised proposal, in an average year,
20 from the base of 55 percent contract entitlement, they will
21 receive 25 to 45 percent. And in a dry year, 20 to 30 percent
22 of their contract supply. And these figures, Your Honor, are
23 set forth in San Luis Exhibit I at paragraphs 9 and 10 and San
24 Luis Exhibit J at paragraphs 7.
25 For municipal and industrial contractors, CVP



1 contractors south of the Delta, in an average they would go
2 from a base supply of 80 percent to a 50 percent supply under
3 the plaintiffs' proposal. And the same number for a dry year.
4 And that, Your Honor, can be found in San Luis Exhibit J in
5 paragraphs 5 and 7.
6 The declarations of Russ Freeman, Westlands Water
7 District, San Luis Exhibit L; William Harrison, San Luis
8 Exhibit M; and Daniel Nelson, San Luis Exhibit K, translate
9 those shortages into the fiscal impacts within the CVP service
10 area.
11 Mr. Freeman's declaration describes how the loss of
12 CVP water within Westlands would affect the lands within
13 Westlands. As he explains, it would be a much increased
14 reliance on groundwater with risk of subsidence, land will be
15 fallowed, with all the consequent impacts, including dust
16 emissions.
17 Mr. Harrison's declaration describes the impacts in
18 the Del Puerto Water District. As he describes, there are
19 23,000 acres of row crops within his district. Under
20 plaintiffs' proposal and zero allocation, there will be no
21 water for that land.
22 Finally, Mr. Nelson, who was executive director of
23 the San Luis and Delta-Mendota Water Authority declares that
24 similar impacts will be felt throughout the remaining service,
25 ag service districts.



1 There's municipal industrial impacts which are
2 described in declaration of Joan Maher, the State Water
3 Contractors exhibit. In a word, Your Honor, the impacts of
4 plaintiffs' proposals in particular would be brutal within the
5 CVP service area. The other measures are not much better.
6 And again, pose severe, severe shortages.
7 I'll briefly address the measures to limit
8 entrainment at the project pumps. There's been lots of debate
9 about what the levels reverse flows should be allowed. In all
10 the analyses, though, one important factor was left out. Both
11 in the analyses by the DWR and the analysis put forth by the
12 plaintiffs by Dr. Pete Smith. That is none of those analyses
13 considered abundance in their calculations. And accordingly,
14 they overstate the effect of reverse flows on salvage.
15 With respect to action number ten, in the plaintiffs'
16 proposal, fall outflow requirement, Dr. Miller did what we
17 think is a very practical and sensible analysis, which is to
18 ask whether in past years of high fall outflow more delta
19 smelt were produced.
20 So he analyzed whether, in those high outflow years,
21 the fall midwater trawl index went up, either within the same
22 year or in the subsequent year. And the answer is no.
23 There's no relationship. And that's in San Luis Exhibit F.
24 And I won't respond further to counsel's comments
25 about Dr. Miller other than to say to his analogy, tomatoes do



1 not eat gloves.
2 There's uncertainty under all of these proposals. If
3 anything characterizes the basis for these actions, it is
4 uncertainty. There is no quantification of the benefit that
5 each measure will provide in terms of increased abundance of
6 delta smelt. There's been no comparison, even, of what the
7 abundance will be with and without the measures.
8 Plaintiffs at least say no one can estimate how many
9 delta smelt there are or how many there need to be to ensure
10 their long-term survival.
11 I disagree with counsel that this case is like TVA
12 versus Hill. It is not anything like TVA versus Hill. In
13 that case, it was undisputed that completion of the dam would
14 cause the extinction of the snail dart.
15 Here, what the projects are, what the benefits of
16 their proposed measures will be are very much in dispute and
17 very uncertain.
18 The Court asks about vacatur of the Biological
19 Opinion. We would urge the Court not to vacate the Biological
20 Opinion. The Court has concern about the incidental take
21 statement in that Biological Opinion, that it's outdated, that
22 it doesn't reflect current abundance levels.
23 Our suggestion would be that in its order of remand
24 without vacatur, the Court could set a time for the Fish &
25 Wildlife Service to develop a new incidental take statement.

There is some time to do that before take would occur again as a result of project operations.

THE COURT: Let me ask Mr. Maysonett. Is that feasible?

MR. MAYSONETT: Your Honor, an incidental take statement is written as part of the Biological Opinion. It's an issue that the service is going to be developing as it develops a new Biological Opinion. Until the analysis, the opinion is complete, I don't know that it makes sense to require the service to write a separate interim incidental take statement.

THE COURT: Thank you. You may proceed, Mr. O'Hanlon.

MR. O'HANLON: Thank you, Your Honor. Plaintiffs' counsel said that the federal government has the burden of proof here. I disagree. The cases that plaintiffs cite all involve circumstances where the action agency was found to be in violation of its obligations under Section 7(a)(2) as the Thomas v Peterson case and the Washington Toxics case.

This Court in its summary judgment ruling did not find that reclamation is in violation of its obligations under Section 7(a)(2). Those cases are inapposite. The burden is on the plaintiffs and it is their burden to prove that the Bureau of Reclamation's assessment of its obligations are arbitrary and capricious.



With respect to a remedy proposal, Your Honor, I cannot in good conscience endorse on behalf of my clients any of the remedy proposals currently before the Court.

As the Court knows, we do not believe that the projects are the cause of the decline of the delta smelt, including particularly the recent decline since 1999. We do not believe that imposing further restrictions on the projects will provide any benefit to the delta smelt. However, those measures will impose severe impacts as I described.

Your Honor, this phase of the case is certainly not the end of this case. No doubt there will be further consideration of what is causing the decline of the delta smelt and what is necessary to address that. Every biologist that came before the Court agreed that the decline of the delta smelt has many causes. Invasive species, toxics, food limitations, in-Delta diversions, there's a lengthy list.

But repeatedly, and for years, all of the focus has been on the projects. The measures imposed on the projects benefit the smelt and look where that what has gotten us. Look where that has gotten the delta smelt. Look where that has gotten those who depend on the projects for their water supply.

What must happen is that the same focus that has been put on the projects must be brought to bear on the other factors that are affecting the delta smelt. And we will



continue to advocate for that. And we may come to this Court at a later time for assistance with that. Thank you, Your Honor.

THE COURT: Nobody has commented on Dr. Miller's suggestion that the food supply be studied. Seems to me like that's an excellent selection. I don't know why you wouldn't do it, but there apparently is no discussion of it. His proposal that a preserve be established with a million here and a million there sounded a little ambitious to a non-biologist. And so I'm not clear whether that would be feasible or not feasible. But certainly there are more issues to look at.

MR. O'HANLON: Yes, there are, Your Honor.

THE COURT: Thank you, Mr. O'Hanlon.

Mr. Buckley, now is your time.

MR. BUCKLEY: Thank you, Your Honor. Your Honor, particularly given the lateness of the hour, I appreciate the opportunity to address the Court. I'd like to start off by making three very basic points and then expand a bit.

First of all, based on the evidence presented by Dr. Miller, and we think worked on by others, we don't believe that any restrictions on pumping, even a total shut down of the projects, is going to make a difference in the long run for the delta smelt.

We do not believe that the projects are appreciably



increasing jeopardy to the survival of the delta smelt. Which we believe is the issue. We believe that the fate of the delta smelt is going to be determined by how other factors are resolved, particularly the food supply factor to which Your Honor alluded a moment ago. However, Your Honor has indicated an intention to implement a remedy.

THE COURT: Well, I'll tell you why. How can it be denied that the Old and Middle River flows, reverse flows don't have an impact on the smelt and don't move the fish to their extinction or at least extinguishment. I'm not talking about the species. That I think is indisputably established by the evidence. There isn't anybody who says that doesn't happen.

MR. BUCKLEY: Well, Your Honor, I think there's a distinction. I don't think anybody said that fish are not entrained at the pumps. And I didn't hear anybody say that the flow problem at Old and Middle Rivers doesn't have an impact on that.

The real question, however, is whether, even if entrainment occurs, it has any effect at the end of the day on the abundance of the species. And we think --

THE COURT: Oh, I heard Dr. Hanson say that you would take a quarter of the population that's in the central Delta in its migratory phase and essentially push it into the south Delta where we know it's either going to die or be salvaged.

1 MR. BUCKLEY: But the -- but when you analyze the
2 question whether the abundance of the smelt has been affected
3 by any of these things, X2, outflows, entrainment, the exports
4 generally, the answer is always no.
5 And Dr. Miller is not an outlier, he's not a crack
6 pot. He's not somebody who is rounded up to come in here and
7 make these representations. Other people, as he testified,
8 have tried to make the same correlation, have tried to
9 determine whether any of these factors have an effect on
10 abundance and nobody has been able to do it.
11 And our position basically is that given all of the
12 correlations that have been done, even when -- even when the
13 smelt were close to the pumps, Dr. Miller took the worst
14 years, the years when it could be established that the smelt
15 were closest to the pumps, and looked for an impact on the
16 abundance of the species as measured by the fall midwater
17 trawl and found nothing.
18 So, you know, our view is that regardless of the
19 extent of entrainment, the problem with the species is not
20 being affected -- that the well being of the species is not
21 being affected at the end of the day by the projects, but by
22 other things.
23 The -- let me just move on and make my second point
24 because I'd like to kind of get back to the cause issue. You
25 asked, I think, each of us to come to a view as to whether we



1 would support a remedy or had a view on a remedy and what our
2 view was. Speaking for the Farm Bureau, and understanding
3 that Your Honor intends to implement a remedy, we -- and
4 understanding the impact that any remedy the Court enters is
5 going to have, as just described by Mr. O'Hanlon, we would
6 support the remedy that has been proposed by the Fish &
7 Wildlife Service as amended by the suggestions made by the
8 Department of Water Resources.
9 Understanding that Your Honor is going to enter a
10 remedy, implement a remedy, we believe that that's a remedy
11 that is overly protective, particularly given our view that
12 the projects are not, at the end of the day, going to affect
13 the well being of the species one way or the other. And also
14 given the tremendous --
15 THE COURT: You understand the doctrine of
16 contributing cause?
17 MR. BUCKLEY: I do, Your Honor, but the question
18 is --
19 THE COURT: Tort law. And you're telling me, as Mr.
20 O'Hanlon did, that the operation of the projects are not a
21 cause?
22 MR. BUCKLEY: I'm telling Your Honor that my -- our
23 view is that the operation of the projects is not appreciably
24 increasing the jeopardy to the survival of the species, that's
25 right. And we do not see any evidence that that's the case.



1 Everybody who's looked for evidence that that's the case has
2 failed to find it.
3 There's no question that fish are dying at the pumps.
4 There's no question that we don't have an accurate count of
5 that. There's no question that the fish dying are not just
6 sub-adults and adults, but also juveniles who are so small
7 that they can't be found and measured. But at the end of the
8 day, every analysis aimed at finding an impact on --
9 THE COURT: We had the analysis by Dr. Miller, but we
10 may have been in different courtrooms.
11 MR. BUCKLEY: Well, but, Your Honor, Dr. Miller
12 testified he's not the only one who's tried to do this. He
13 mentioned other people. He mentioned Dr. Manly, who's one of
14 the foremost statisticians, ecological statisticians in the
15 world. He mentioned Dr. Kimmerer, who hasn't appeared in this
16 courtroom on behalf of anyone.
17 It's not Dr. Miller alone who has made an effort to
18 find the correlation between the project and abundance. And
19 the testified he looked every way he could. He used every
20 analytic technique he could think of, he used every
21 combination of years he could think of and he couldn't find
22 anything. And he said -- he testified that other people have
23 made the same effort he's made and no one has been successful.
24 THE COURT: There's one last point I'm going to make.
25 I'm not arguing with you, but I want you to understand. You



1 aren't the only parties here. The party who has
2 responsibility under the law of protecting the species is
3 here. That's the federal government through its Department of
4 Interior and the action agency, the Bureau of Reclamation.
5 And what I do see and what the evidence does show the
6 Court is that there is more to be done than they are doing.
7 Now, that doesn't have anything to do with you, but it does
8 impact you. And the impacts are extreme and severe. There's
9 no question about it.
10 MR. BUCKLEY: Well, I think a question that has been
11 addressed at considerable length here is whether the projects
12 are doing enough. And I've sat now through at least two
13 hearings and listened to Your Honor, and I think I know what's
14 concerning the Court.
15 The concern is whether the Bureau of Reclamation is
16 going to do what it's supposed to do. Whether when certain
17 triggers are reached, indicating that there may be a problem
18 at the pumps, the Bureau of Reclamation is going to take the
19 action its own triggers, if you will, indicate it should take
20 or whether it's going it rationalize away somehow the need to
21 do that. Whether it's in the interest of exports or for some
22 other reason.
23 I think that was probably what bothered Your Honor
24 with the DSRAM process. It was too discretionary and Your
25 Honor was concerned that there was some evidence in the record

1 that it wasn't being used in an objective way to protect the
2 species.
3 And so I think I understand where you're coming from
4 and I do understand that you intend to implement a remedy.
5 THE COURT: I'm not being facetious because I have
6 the utmost respect for Mr. Milligan and I very much
7 appreciated his testimony and I learned a lot from his
8 testimony. But in a way it does sound like DSWG, those are
9 the scientists, they meet, they study, they recommend, the
10 WOMT then looks at it, it's complicated, there are so many
11 competing issues, they're impossible decisions to be made, so
12 then it goes to the department heads or the agency heads and,
13 again, I'm not being disrespectful, sounds to me like the
14 agency heads get on planes and head to Washington. And here
15 we are.
16 MR. BUCKLEY: I recognize that, Your Honor. And I
17 think I would expect that Your Honor is considering some ways
18 of dealing with that. Time limits, other ways of
19 strengthening the process so that an objective result is
20 reached in the interest of the species. The problem is that
21 if you hardwire a solution which doesn't allow for the
22 dynamics in the system and the permutation and combinations of
23 things that can happen --
24 THE COURT: I'm going to be getting to this, but the
25 law doesn't permit me to hardwire anything.



1 MR. BUCKLEY: I agree, Your Honor.
2 THE COURT: I can't interfere with the agency's
3 discretions, I can't run the projects. I suppose in a
4 theoretical sense I can tell them what to do. But that's
5 neither my inclination nor what the law provides for.
6 MR. BUCKLEY: I recognize that, Your Honor, and I
7 agree with that.
8 Let me just sum up my discussion of the causation
9 point by saying that, as I might have said a moment ago, given
10 all the work that's been done to determine whether the
11 projects have an impact on the abundance of the species, you
12 would expect that somehow somebody somewhere would have found
13 a correlation between any of these projects involving the
14 factors of the abundance of the species. And that really
15 hasn't happened.
16 I'd like to turn to one other thing. And that
17 is -- well, if is isn't the projects, what is it? And Your
18 Honor, I think heard Dr. Miller yesterday and alluded to the
19 food problem today. And I'd like to touch on that briefly.
20 We know, not because of any statistical analyses really but
21 because of data collected that species have transformed the
22 Delta's ecosystem.
23 As Dr. Miller testified yesterday, if you ran a net
24 through the Delta's waters, 95 percent of the fish you catch
25 are alien species. We know that the summer abundance of the



1 zooplankton Eurytemora crashed in or about 1986 coincident
2 with the arrival of two clams, Corbula and Corbicula, which
3 Your Honor has heard a great deal, fresh water clam and salt
4 water clam. Why did this crash occur? Because these clams
5 eat zooplankton, including Eurytemora. We know that
6 Eurytemora was replaced when it crashed in 1986 by another
7 zooplankton, Pseudodiaptomus, which is an alien.
8 THE COURT: And two more species that we heard about
9 in the rebuttal testimony from Dr. Swanson, not mentioned by
10 anybody. So I think on that score that that's an uphill --
11 MR. BUCKLEY: Well, I want to get to that, Your
12 Honor, let me deal with it right now. Dr. Miller did testify
13 yesterday that he -- the reason he chose those two species to
14 study was because he talked to a lot of biologists and was
15 told that those two species were the principle food source for
16 the -- for the delta smelt. And so he used them. He wasn't
17 told that Limnolthona was a principle food source, he was told
18 that Eurytemora and Pseudodiaptomus were. So those were the
19 species he used.
20 Furthermore, Dr. Swanson's testimony to the effect
21 that there are other species, there are other species of
22 zooplankton that the delta smelt eats doesn't explain away the
23 very tight, almost overwhelming correlations that have been
24 developed with respect to the abundance of the delta smelt and
25 the abundance of those two species. It's an unbelievable fit.



1 It has an R-squared of way over 80 percent.
2 So you can say, well, there are other -- there are
3 other things that the fish eat. But when you look at it, when
4 you statistically analyze it, you see a clear relationship
5 between the abundance of those two zooplankton species and the
6 abundance of the delta smelt.
7 We think that Dr. Miller has established a very
8 powerful correlation between those factors. It's a
9 correlation that leaves less than a one in 25,000 likelihood
10 that the correlation was achieved by chance. He did the same
11 thing with longfin smelt and achieved an even tighter
12 correlation. And I would add that I think, as Dr. Miller
13 testified in response to the questions from the Court
14 yesterday, it's not as though he's totally out there a voice
15 in the wilderness. He was the first person to get on this.
16 But in recent months, I think it would be fair to say, that
17 this finding is achieving traction and it's starting to be
18 discussed.
19 Dr. Moyle, for example, testified on the first day of
20 the proceedings, and I refer Your Honor to page 61 of the
21 transcript of the first day, that he agreed that inadequate
22 food supply was a cause of the decline in delta smelt
23 abundance. Dr. Miller established that it wasn't just a
24 cause, it was the overwhelming cause. We -- I'm sorry, Your
25 Honor, go ahead.

THE COURT: I'm not meaning to be inattentive, but even with my questions, you're way beyond seven minutes that you had --

MR. BUCKLEY: All right. Your Honor, I'll just sum up by saying that I recognize the projects are essentially the only knob you have to turn. But in view of -- at least in our view, that the projects --

THE COURT: Let me ask you one rhetorical question.

MR. BUCKLEY: Yes.

THE COURT: Why is it, do you suppose, that given what we're facing here, the consequences for everybody, that the action agencies, both the state and the federal, didn't essentially come in and say it's the food supply? It's other causes, it has nothing to do with our projects and we cannot be accountable for this. They didn't do it.

MR. BUCKLEY: I think if I were asked that question, Your Honor, on direct examination, I'd probably -- or somebody would probably object to it because I'd be getting into the minds of the government. I don't know the answer to that question. But --

THE COURT: Well, there is something you could draw an inference by, but I think we're out of time to do it.

MR. BUCKLEY: I would just ask, Your Honor, in turning the knob I know you intend to turn, you take into account the significant impacts that will result.



THE COURT: Thank you very much, Mr. Buckley.

MR. BUCKLEY: Thank you, Your Honor.

THE COURT: Mr. Wall, are you going to reply?

MR. WALL: Hit a few key points very quickly.

First, Your Honor, the defendants have tended to agglomerate the Fish & Wildlife action three and four. They're very different. Action four is a process. It doesn't have any hard sideboards on flow.

Second, when asked, the operator, Mr. Milligan said this morning that ultimately the operators, he means the bureau, had the final say on how to implement or whether to implement proposals.

Third, Dr. Swanson's tier one measure has as its apparent basis particle tracking modeling. Tier one is supposed to protect adult smelt. Adult smelt do not behave like particles. Of course, his Particle Tracking Modeling has never been presented even at a scientific form let alone published. So I'm hard pressed to understand counsel's criticism of Dr. Swanson's reliance on Dr. Bennett's research.

Fourth, Dr. Hanson has proposed a rather wide range in his declaration of minus 1,000 to minus 6,000. But at trial, he said in light of the new evidence about the abundance of delta smelt, he would recommend operating at the low end of that range.

He says, and this is at page 100 of the 8-29



transcript, "With the lower number of delta smelt in the population, it would strongly urge that more protective actions, hence operating at the lower ends of the ranges Old and Middle River flows, would be an appropriate action in the event that there's evidence that delta smelt are at risk of salvage mortality."

And of course that's when he's implementing his tier two, when there's risk of salvage mortality. He is testifying -- he does it again at page 149, that he thinks you need to operate at the low end of this range. Well, Dr. Swanson's proposal is at the end low end of the range. Minus 6,000 cfs is not.

THE COURT: Where is his low end?

MR. WALL: Minus 1,000. You know, he would have been somewhere closer to minus 1,000 than minus 6,000, I suppose.

With respect to the Feyrer article, I think this has been repeatedly mischaracterized. They did find a relationship between habitat quality and delta smelt abundance. They found that one complement of habitat quality, salinity, accounted for 19 percent of delta smelt abundance.

There is this caveat at the end, it says, "For the water quality data to be most effective for species management, additional information is needed to better define the mechanisms for the effects of water quality variables on aquatic organisms."



But nonetheless, they found this relationship and we know that improved habitat improves the opportunities for delta smelt to survive. There is no dispute about that.

There was a question about the US Fish & Wildlife Service's acceptance of the proposed modifications before the DWR and I do not know the government's position. But I would refer the Court to Ms. Goude's testimony, both in her declaration and at trial, where she says that the various actions identified in her proposal are expected to provide the minimum in protective actions necessary to protect delta smelt.

She said that in her August 3rd declaration at paragraph 9 and she said that again in her August 23rd declaration -- or testimony at page 220.

If the Fish & Wildlife Service were now to conclude that these proposals were not the minimum action based on the few minutes of hallway consultation, I would submit it's the world's faster Section 7 consultation and directly inconsistent with her prior testimony, sworn testimony to this Court.

There is also some discussion of the Delta Smelt Working Group rejection of a fall action. The Delta Smelt Working Group looked at a fall action that had a lower flow level than Dr. Swanson's and found that it would not move the salinity point out far enough. Dr. Swanson took that into

1 account and proposed a higher outflow level that would move
2 the salinity point out far enough.
3 Lastly, I want to just address the issue of
4 protection of salmon very quickly. There has been no
5 calculation that the available water supply at the different
6 reservoirs, including New Melones, which is over its historic
7 average, is insufficient to protect salmon if these measures
8 are implemented.
9 I'm sure the Court is aware that my clients are also
10 interested in protection of salmon. We would not be proposing
11 this measure if we had any reason to believe that it would
12 harm that species.
13 That's it, Your Honor. Thank you.
14 THE COURT: Thank you very much, Mr. Wall. Mr.
15 Maysonett.
16 MR. MAYSONETT: Your Honor, I have an answer to the
17 question you posed to the federal defendants before about
18 whether or not the federal defendants accept the modifications
19 to the service's matrix.
20 THE COURT: Yes.
21 MR. MAYSONETT: Your Honor, short answer is no. The
22 slightly longer answer is that, you know, the proposed
23 changes, Your Honor, would be this movement from -- I'm
24 looking at DWR Exhibit L, in action two from negative 4500 to
25 negative 5500 and then, in action three, from a floor of zero



1 to a floor of negative 1500.
2 THE COURT: All right. Thank you very much.
3 MR. MAYSONETT: And I would just say, Your Honor,
4 that, well, the short answer is no. The long answer is that
5 the service's proposal is grounded in the other assumptions
6 that are set out in the service's proposal. For example, use
7 of a 14-day running average and the process for setting this
8 level is described in the attachments. I think those to some
9 degree address some of the concerns with those lower flow
10 levels. If these numbers were taken out of this proposal, the
11 service's -- the position of the federal defendants might
12 change.
13 THE COURT: Thank you very much, Mr. Maysonett.
14 Is the matter submitted?
15 MR. WILKINSON: Yes, Your Honor.
16 MR. WALL: Yes, Your Honor.
17 MR. LEE: Yes, Your Honor.
18 MR. O'HANLON: Yes, Your Honor.
19 MR. MAYSONETT: Yes, Your Honor.
20 THE COURT: All right. I'm going to start by
21 reviewing the law that applies in this proceeding. And as I
22 have said, based on the recent amendment by way of supplement
23 to the complaint, we have action that is alleged to be
24 unlawful or omission by an agency of the United States, the
25 DWR. I'm sorry, the Bureau of Reclamation as well as the



1 Department of the Interior. That the way in which the Central
2 Valley Project is being operated is both presenting present
3 jeopardy to the survival and recovery of the species and that
4 it is also impairing the critical habitat of the species.
5 And the ESA prohibits agency action that is likely to
6 jeopardize a continued existence of any listed species, and in
7 this case, the delta smelt is listed as a threatened species.
8 And the regulations, that's 16 United States Code, Section
9 1536(a)(2) referred to as Section 7 of the ESA, 7(a)(2)
10 violation.
11 And the regulations that are at 50 CFR, Section
12 402.02 provide that this law prohibits any agency action that
13 reasonably would be expected, directly or indirectly, to
14 reduce appreciably the likelihood of both the survival and
15 recovery of a listed species in the wild.
16 The word "jeopardize" or "jeopardy" as it is used in
17 the act means to engage in an action that reasonably would be
18 expected, directly or indirectly, to reduce appreciably the
19 likelihood of both the survival and recovery of a listed
20 species in the wild by reducing the reproduction numbers or
21 distribution of that species.
22 The complaint also sought and a summary judgment in
23 the case has been entered that essentially found the 2004/2005
24 Biological Opinion that covered the operation of the OCAP for
25 the, if you will, day-to-day running of these coordinated



1 projects and operations of the State Water Project and the
2 Central Valley Project. That finding was that the Biological
3 Opinion was unlawful, arbitrary and capricious for the reasons
4 that are stated and they don't need to be stated now because
5 that has already been decided.
6 The further finding was that the decision of, in
7 addition to the Biological Opinion, that the remedial action
8 measures that had been adopted as part of that decision and
9 belated actions and also a take limit that has been
10 established as required by the Endangered Species Act was also
11 invalid.
12 After those findings, the Court set, in consultation
13 with the parties, this evidentiary hearing, which has now
14 consumed eight full court days, to determine what remedies, if
15 any, should be imposed by the Court to address the unlawful
16 actions by the Department of the Interior and the Bureau of
17 Reclamation, the latter is the action agency.
18 The State Department of Water Resources, which is a
19 coordinated operator of the State Water Project, which is
20 operated in tandem and cooperatively with the federal project
21 and, as the parties all know, the federal project has state
22 permits for its water entitlements that are used to perform
23 its operations both of water service, that is performed under
24 contract to water districts, who in turn have members who
25 contract for water.

1 And we have constituencies here, not only San Luis
2 and Delta-Mendota Water Authority, Westlands Water District,
3 Del Puerto Water District, Glenn-Colusa Irrigation District.
4 We have the State Water Contractors, who include not
5 only contracting districts, but also municipal and industrial
6 agencies who provide water service that isn't for agricultural
7 purposes, it is for municipal purposes.
8 And additional to those parties are the Farm Bureau,
9 who we have just heard from.
10 In addressing the remedial approach to the case, the
11 plaintiffs have sought initially for the invalidation of the
12 Biological Opinion and a vacatur of the take standards and all
13 aspects of the Biological Opinion. Today in argument, they
14 offered that if -- and I interpret the offer as a conditional
15 offer, the condition being that if the Court were to pronounce
16 and apply the remedies that are in the revised recommended
17 interim protection actions for delta smelt that Dr. Swanson
18 has authored, if all of those are adopted as a remedy in the
19 case pending the reconsultation, remand and, if you will, the
20 correction and/or repromulgation of a lawful Biological
21 Opinion, that that would be acceptable to the plaintiffs.
22 The federal defendants have, after taking the initial
23 position that there was no entitlement to relief because there
24 were no violations of law, they haven't waived those
25 positions, say that if there are remedies to be imposed, that



1 for all the reasons that have been stated by their witnesses,
2 primarily Cay Goude, that the five featured action matrix
3 should be pronounced by the Court to be a remedy that is to be
4 operative in the interim period between today and the time
5 that a lawful Biological Opinion is issued concerning the OCAP
6 for the Central Valley Project and the State Water Project.
7 The Department of Water Resources, as intervenor,
8 essentially for the reasons stated by Mr. Lee, agrees with the
9 proposed action matrix of the Fish & Wildlife Service and
10 would modify to make, if you will, less stringent the flow or
11 water consumption requirements.
12 The State Water Contractors, without waiving their
13 position that the original BiOp was lawful and that no
14 remedies are needed, have proposed an alternative three-tiered
15 remedial approach. And they do not agree with the Fish &
16 Wildlife Service, I'm just going to call it the federal
17 defendants' proposed remedy and/or the modification to that
18 remedy proposed by the Department of Water Resources.
19 The Delta-Mendota Water Authority and Westlands Water
20 District intervenors, one, do not believe the BiOp is
21 unlawful, have not waived that position. They, joined by the
22 Farm Bureau, take the essential position that the evidence in
23 this proceeding, through Dr. Miller's testimony, has
24 established that there are a number of causes for the decline
25 of the delta smelt, including but not limited to toxicity,



1 predation, the disappearance or reduction of the food supply
2 caused in material part by the invasion of alien species,
3 primarily two types of clam that filter the planktonic
4 organisms that are the food supply to the smelt, among others.
5 They also believe that in-Delta actions by other
6 diverters, who are not under the direct control or operation
7 of either the state agencies and meteorological conditions,
8 such as storms, winds, temperature changes and the like, all
9 have effects on the movement, the existence, the location and
10 the health of the species.
11 And so the San Luis and Westlands defendants agree to
12 nothing and essentially do not support any remedy. They say
13 there should be no remedy because the projects have no causal
14 relation that is significant to any of the problems the smelt
15 is now encountering or has encountered.
16 The Farm Bureau takes the same position, but
17 arguendo, if a remedy is going to be imposed, support the
18 federal defendants' five point action matrix as modified by
19 the Department of Water Resource proposals.
20 This case is also brought under Title 5 United States
21 Code, Section 702, et seq. United States Administrative
22 Procedure Act and it addresses action by an agency of the
23 United States that is arbitrary, capricious or unlawful, which
24 requires the intervention of Court to make such a finding.
25 And Mr. Wall was very accurate in his recitation of



1 the law. It is not the function nor necessarily the
2 jurisdictional authority. It might be the prerogative, but in
3 the eyes of this Court, deference is required by law to an
4 agency that has the expertise, the competence and the legal
5 charge that is essentially invested by the elected
6 representatives of the people who make the laws and then
7 charge experts in the executive branch to carry out the
8 functions of the agency, here the operation of the projects.
9 And so a judge, who is neither a scientist, a
10 biologist, an administrator or elected by the people,
11 ordinarily is confined to determining the legality of actions
12 and, if necessary, and appropriate -- and here, I take it that
13 because of the alternative positions that are taken by the
14 governments, and I'm more concerned with that of the federal
15 defendants because by their consent and waiver of any Eleventh
16 Amendment immunity, the state is here, they have acquiesced to
17 the jurisdiction and authority of the Court, there by removing
18 the jurisdictional objection.
19 My understanding is that by the position that the
20 United States has taken, they are in effect impliedly, if not
21 expressly consenting to the imposition of a remedy,
22 particularly one without waiving their legal position as to
23 the propriety and legality of their actions as to the BiOp.
24 And also with respect to any finding on the issues of
25 remand, vacatur and the status of the take limits, as I

1 understand the government position, their preference is to
2 consent to a remedy rather than face a remand with vacatur
3 where there will be no effective Biological Opinion or take
4 limits.
5 And we have looked for some time now at the law and
6 we have asked the parties to provide the law, and no party has
7 provided the law that says that the 1995 Biological Opinion,
8 which has obviously been superseded by the government's
9 2004/2005 BiOp. The Court has no understanding that it would
10 have the authority to, if you will, resurrect what is a
11 superseded and obviously outdated, and, if the current one is
12 unlawful, it has to be more unlawful than the current BiOp,
13 recognizing that the take limits in the '95 BiOp were 55,227
14 up to 224,409 delta smelt per year in a dry year.
15 The current incidental take limit was 70,500 and, as
16 the parties all know, nobody knows what the population of the
17 species is, but the '05 BiOp could approach it and the '95
18 take limit very well could exceed it.
19 We have uncontradicted testimony of some experts on
20 the plaintiff side, Dr. Swanson, Ms. Goude, Dr. Hanson, even
21 Dr. Miller told us that the species is in a critical state.
22 It could become extinct within a year and it could become
23 extinct if everything that anybody's asked for here was
24 implemented, it could still become extinct if we put all these
25 measures into effect.



1 It appears to the Court, based on the facts most of
2 which have been discussed by counsel, that the most
3 responsible and the most prudent decision is -- and there's no
4 question that the BiOp has to be remanded and consultation has
5 been reinitiated for repromulgation in lawful form. And so
6 that is one of the remedies that the Court is going to order.
7 The next issue is whether the BiOp is remanded with
8 or without vacatur. And that then presents the Court with the
9 question do we leave the status quo, because the temporary
10 restraining order in this case was not granted and the
11 voluntary pumping cessation, or reduction would be the better
12 description, ended in June.
13 Do we leave the status quo where the agency is left
14 to manage the projects without any intervention by the Court
15 or does the Court impose, with the express or implied consent
16 of the action agencies, remedies that will address the Section
17 7(a) issues of the jeopardy to the species, its survival and
18 recovery, and the impairment or alteration of its critical
19 habitat.
20 And in looking at this question, I asked the parties
21 to consult among themselves and to determine if there was a
22 result they could reach that we could all be proud of. And
23 that effort apparently has not been one that has come to
24 fruition.
25 And so it devolves to the Court to determine what the



1 result should be now with regard to the issue of vacatur or
2 non-vacatur. And in the final analysis, the Court is
3 persuaded by science, which it must be, because the law
4 requires that the best available science be brought to bear on
5 the issues that are presented.
6 As the Court noted and the plaintiffs in their brief
7 on remedies repeated, the law doesn't give the Court a choice.
8 If the Court sees that agency action or inaction not only
9 threatens, but doesn't have to bring it to extinction, but has
10 that potential, then the law requires intervention. There
11 must be action taken by the Court.
12 In this case, given the history, which I have alluded
13 to earlier, that the approach the agencies were taking and
14 here the Court believes that the evidence shows that the
15 Department of Water Resources of the state essentially
16 deferred to the Bureau of Reclamation and Department of the
17 Interior for it to implement the delta smelt Recovery Action
18 Plan and the Delta Smelt Working Group, Water Operations
19 Management Team and the agency heads have certainly addressed,
20 they have spent time on and they have endeavored to remediate
21 the present jeopardy which has been defined as critical.
22 And that was agreed to by the operator, Mr. Milligan,
23 as well as the scientists. And that effort, all those
24 efforts, have been unsuccessful because we see continuing
25 declines and every survey that comes in that we have been



1 furnished in the last two years so shows that the condition of
2 the species is worsening.
3 And so contrary to -- and I do think it is a
4 selective study that was done by Dr. Miller. I'm not
5 criticizing his competence, his ability or the application of
6 his science as an engineer or water engineer, or Dr. Manly's
7 competence or renown as an ecological statistician. But as
8 has been indicated, the correlative studies that were
9 undertaken by those experts certainly provide a major issue
10 about cause. But I think that the answer I got from Mr.
11 Buckley is telling. The law recognizes concurrent causes,
12 even though it's a doctrine that has its origins in the law of
13 torts.
14 But here the Court can't find that the sole cause is
15 the food supply and that the absence of a statistical
16 correlation in the studies that Dr. Miller performed explains
17 the jeopardy of the species when there is indisputable
18 evidence of entrainment, of salvage, the pumps grind these
19 fish up. That's caused by, in some cases, the natural
20 migration of the fishes, it's caused by flow conditions in the
21 central Delta at the confluence of the Sacramento and San
22 Joaquin Rivers, it's caused going east from there, going north
23 from there, going south from there, and those are to the south
24 and into the Clifton Court Forebay areas of hazard.
25 And the evidence is uncontradicted. There isn't any

question about it, that these project operations move the fish. Of course we don't know how many. But the fact is it happens. And the law says that something has to be done about it by the action agency.

Now, the Court from that concludes that it is under a legal duty to provide a remedy. And if it is in the form of an injunction, there would be two standards, the traditional injunctive relief standard and the ESA standard.

The traditional standard looks at the likelihood of success on the merits, it balances hardships, it looks at the public interest; and the ESA standard essentially evaluates the threat of harm to the species and discounts hardships of an economic or other nature, except for human health and safety.

And the Court recognizes that, as I said earlier today, that that isn't just emergency water supplies for schools, for hospitals, for fire departments. That can include the absence of water if the supplies to contractors are zero and land is fallowed, subsidence from groundwater pumping which contributes to the fallowing or the absence of water creates air pollution conditions. Those are threats to human health and the environment, just as the absence of emergency water service is.

How this is going to be accomplished is something that the Court cannot prescribe. Because the law doesn't



permit it. I'm not going to tell the Bureau of Reclamation how to run its agency, how its scientists should think, what conclusions they should reach, what recommendations they should make or how they should be implemented. But I do have proposals that the parties are offering, and I'm going to use those proposals they are offering to do the best in what the Court views as an impossible situation.

In one of these water cases that have been going on for over 30 years in the Eastern District of California involving water supplies to the Central San Joaquin Valley and the Sacramento and central Delta areas, and most of the agencies that are involved in this litigation, Judge Trottin, in one of the decisions said -- this was in the drainage case -- that sometimes problems are so intractable, they're so difficult that they're beyond the competence of the judiciary, they are matters that need to be left to the legislative branch for the legislature to address.

Well, it would be very nice if I could do that. But I can't. Because the law requires otherwise. And I am going to formulate an order and I am going to need the assistance of the parties with this -- to not vacate the 2005 Biological Opinion, but I am going to put into effect a preliminary injunction.

And I recognize the difference between a mandatory injunction and the law's preference for a prohibitory



injunction. And therefore I'm going it to phrase my injunctive relief in prohibitory terms. I'm not playing a game here in trying to exalt form over substance, but rather I'm trying to comply with the law.

And the Court is going to order that Bureau of Reclamation and the State Department of Water Resources take no actions that are inconsistent with or that violate the following remedial prescriptives.

First, there will be year round monitoring actions that fully implement all current surveys that are being conducted for the delta smelt, which will include but not be limited to the Spring Kodiak survey, the 20 millimeter survey, the Summer Townet Survey and the fall MWT.

There was a proposal in what is the second remedial action which would increase the frequency of sampling for entrained fish at the CVP protective facilities to a minimum of 25 percent of the time, which is a minimum of a 15-minute count per hour.

I'm going to also include within that, the measure that was proposed by Dr. Swanson that steps be taken to evaluate presence and condition of larval or juvenile delta smelt that are in the sub-20 millimeter size range, recognizing that there are difficulties in doing that. But as the Court understood it, it's entirely feasible based upon the type of seine or net the interval that would be within the



physical test device itself.

I do recognize that at least two of the experts said that any sampling could be further jeopardizing to the species. But it appears that all parties, with the exception of the San Luis and Delta-Mendota parties, agree that sampling needs to continue and that it is feasible.

The trigger for this that was proposed by the Fish & Wildlife Service was an increase in Delta outflow where the Sacramento River flow at Freeport reached 25,000 cfs or in the San Joaquin River more than 10 percent over a three-day average. And in the fall midwater trawl and/or Kodiak survey data on delta smelt, where fish are moving upstream of the confluence and into the Delta or by January 15th of the water year, whichever comes first.

The next remedial action that will be implemented is -- and I think that I have already in effect adopted action number three of the Fish & Wildlife Service, which was to implement a monitoring program for the protection of larval delta smelt with the trigger that is prescribed. I don't see any reason to modify or to, if you will, change that. And I should correct myself. I'm actually using, at this point, the plaintiffs' remedial actions.

As to the remedial action number three that is submitted by the Fish & Wildlife Service as proposed to be modified by the DWR, the parties can correct me if I'm wrong,

1 but an area of -- and Dr. Hanson spent a lot of time on this.
2 For determining the upstream Old and Middle River flows,
3 rather than adopting a zero cfs as the lower range of that, I
4 remember a lot of discussion about a negative 750 to a
5 negative 2250 range. I recognize that this was not
6 necessarily addressing only larval and juvenile smelt, but the
7 Court is going to adopt the low end of that low range
8 at -- for the third proposed action by the Fish & Wildlife
9 Service at negative 750 to a negative 5,000 cubic feet per
10 second. And the Court thinks that 6,000 is an acknowledged
11 and undisputed area of jeopardy and recognizing that it's
12 easier to -- less consumptive to achieve, the Court is
13 concerned by what it believes are the legitimate reasons given
14 by Dr. Swanson. And in the interest of time, I'm going to let
15 the parties submit findings, which will document the reasons
16 for these choices of remedies.
17 Now, the fifth action is the same as the plaintiffs'
18 actions, which were, if I have them correctly, and the parties
19 can help me here, was it six and seven where we have the head
20 gates at the --
21 MR. ORR: Eight and nine, Your Honor.
22 MR. WALL: Plaintiffs' eight and nine.
23 THE COURT: Eight and nine. All right. Eight and
24 nine are the same, I think, all the parties have acknowledged
25 as Fish & Wildlife Service measure number five. So that would



1 be the next remedial.
2 If you want to do them as two, because I'm going to
3 ask for the parties to prepare an order that is faithful to
4 the decision that I am now announcing. So those remedies are
5 going to be also prescribed.
6 Now, in turning to the plaintiffs' action number four
7 and the triggers, the Court has determined that -- let me have
8 one -- Mr. Maysonett, if you would repeat, please, the
9 objection to plaintiffs' four so I have the basis for it. Or
10 Mr. Lee, either one of you can do that. Mr. Lee was most
11 specific about it. Do you want to address that right now, Mr.
12 Lee?
13 MR. LEE: Number four, as I understand it, is
14 designed to protect pre-spawning adults. I'm talking about
15 revised number four set forth in plaintiffs' proposal
16 contained in the August 13th, 2007.
17 THE COURT: That is correct.
18 MR. LEE: And that proposal would start out -- is
19 multi-part, as I understand it. They would have a zero cfs
20 requirement for a minimum ten days and then -- and then
21 following that, there would be a requirement that would have
22 Old and Middle River flows between 2750 and 4250 cfs.
23 We had objected to the zero flow because we did not
24 believe there was any science in the record to support it.
25 The zero flow, as I understand this requirement, is roughly of



1 the same nature as in action number one in US Fish & Wildlife
2 Service measure. And that had a negative 2,000 cfs, which we
3 believed science fully supported.
4 So we would have recommended that the Court adopt
5 action number one for that time period for -- under the US
6 Fish & Wildlife proposal.
7 As to the follow-on proposals, we submitted that,
8 first of all, the five-day running average was inappropriate,
9 it should be a 14-day running average or seven-day running
10 average subject to some bans and constraints.
11 But most importantly, we were of the view that the
12 range of flows was too narrow, that the flows should be,
13 according to our view, not in excess of -- sorry, make sure I
14 got right -- negative 5500 for a 14-day running average or
15 negative 6,000 for a seven-day running average. As you can
16 see, as the running average days get shorter, the band gets
17 larger. As the running average days get longer, the band, the
18 level of authorized exports, gets lower. So that was our
19 proposal for the protection of pre-spawning adults.
20 And our objection to action number four is we did not
21 believe it was supported by the regression analysis submitted
22 to the Court which we discussed in closing argument. Is that
23 clear?
24 THE COURT: That is clear. But you did have a
25 proposal that covered in part this time period?



1 MR. LEE: Yes, we did, Your Honor. The two -- the
2 two-part proposal, one would be action one in the US Fish &
3 Wildlife Service proposal. The other would be a modification
4 of action two of the US Fish & Wildlife proposal. And that
5 modification would read -- and I would just look at action two
6 and put in the State's modifications -- the daily net upstream
7 Old and Middle River flow not to exceed 5500 cfs. The low
8 will be a 14-day running average simultaneously, the seven-day
9 running average will not exceed 6,000 cfs. That would be the
10 proposal for this lifestage of the smelt, which is the
11 pre-spawning adult smelt.
12 THE COURT: And the State Water Contractors have
13 proposed that this start December 1st. I'm going to leave it
14 at December 25th. I'm going to essentially reduce those flows
15 from 6,000 on the seven-day running average to 5,000 cubic
16 feet per second. And there was objection to the 14-day
17 running average -- well, you had proposed a 14-day running
18 average. Leave it at the seven-day running average and don't
19 do a 14-day running average.
20 MR. LEE: So, in effect, Your Honor, you're adopting
21 one-half of action two of the US Fish & Wildlife proposal?
22 They have a 4500 cfs average for a 14-day running average and
23 a 5,000 cfs for a 7-day running average. Are we abandoning
24 the 4500 cfs.
25 THE COURT: What does it add?

MR. LEE: I'm sorry?
THE COURT: What does it add?
MR. LEE: I would probably defer to the US biologists. They are --
THE COURT: Do you know, Mr. Maysonett?
MR. MAYSONETT: Your Honor, my understanding is that the targets of 4500, negative 4500 negative flow in the Old and Middle River is 14-day average and that by -- the 14-day average, of course, allows certain ebbs and flows of the tides and the other influences that is hard for the projects to operate to eliminate entirely.
The seven-day average at negative 5,000 would help to limit the highs and lows a bit. So my understanding is that the two work in tandem to ensure that flow levels remain in certain -- within a certain range.
THE COURT: All right. Well, I'm going to order the prescription that I've just described. And if we have to adjust the language, we will.
As to action measure number ten. The Court is not persuaded that the evidence preponderates here to support this action. It was very well explained by Dr. Swanson. The justifications were very articulately presented. It does not appear to me that there is support necessarily in peer reviewed or analysis by others who are studying this issue.
The Court certainly recognizes that water quality and



the improvement of habitat has the potential to increase benefit to the species. But I am very impressed by the fact that the Delta Smelt Working Group, one or two of whom essentially were presented with this proposal in a different form, in a different context, but didn't support it.
And because of the material uncertainty that is described by reviewing scientists about the benefit at a very, very large commitment and a -- resource commitment, the Court does not believe that the evidence preponderates to justify this measure and therefore it will not be included in the remedies.
And so if I have it, then, we have those that I've just gone over. And I'll now invite the parties to -- action nine is the same as, I believe, five of the Government's Fish & Wildlife Services, that is to prohibit installation at the Head of Old River Barrier in connection with the triggers and the end of the actions. Those are agreed on. And the other management of the gates, which was, I'm going to indicate -- well, I don't see it.
I don't see, Mr. Orr, number six, that's implementing the Vernalis Adaptive Management Plan river flow and enhancement, I am going to order that as a prescriptive remedy.
And so I believe I have addressed the remedies that I intend be prescribed as part of the injunctive relief. If



anybody wants to address anything now that you believe has either been overlooked or not addressed, now is the time to do it.
MR. WALL: Your Honor, I have a couple of clarifying questions.
THE COURT: Yes.
MR. WALL: If I might. The first half of plaintiffs' four parallels the Fish & Wildlife Service one and I didn't hear if the Court was doing anything with that.
THE COURT: I'm adopting it.
MR. WALL: Fish & Wildlife Service one?
THE COURT: Yes.
MR. WALL: Okay. And the -- you were also adopting the plaintiffs' eight and nine, which are the same as plaintiffs' Fish & Wildlife Service five?
THE COURT: Yes. And six, that were agreed to by all the parties except Mr. O'Hanlon's clients.
MR. LEE: Your Honor, just for the clarity of the record, we did not agree to action six. The reason why we -- oh, let's see. The reason why we did not agree to it is because action six is basically the implementation of the Vernalis Adaptive Management Plan. And that is mandated already on the projects by water right decisions. We had noted in our, I believe it was cross examination, that this was unnecessary.



THE COURT: Well, it might be redundant, but out of an abundance of caution, we have it. Let's include it in the order.
MR. WALL: Your Honor, if I could, one other clarifying matter. The Fish & Wildlife Service had action four, which is post VAMP, and we had an action seven, which is post VAMP. Did the Court intend anything for the post VAMP period?
THE COURT: I thought that there was a -- let me have what the Fish & Wildlife Service's proposal was on post VAMP. It is number --
MR. WALL: Number -- Fish & Wildlife Service action four.
THE COURT: Four. I had ordered that. And I had not -- I modified it to take the low flow from zero to minus 750. Negative 750.
MR. LEE: Your Honor, it is my understanding that action four, in its original format with the US Fish & Wildlife Service, was intended to have flows similar to those in action three. And we've mentioned that in, I believe, footnote 1, was that not the case? Of attachment B. If the Court's view is that action four should simulate action three, then --
THE COURT: The flow levels would be the same.
MR. LEE: The flow levels would be the same. Is that

your desire?

THE COURT: That is what I was attempting to describe.

MR. WALL: So action three would be extended to last until the end of -- the end date for action four? Basically action three would continue on?

THE COURT: That is correct.

MR. WILKINSON: And Your Honor, those flows again were a range of negative 750 to negative 5,000; is that correct?

THE COURT: That is correct.

MR. LEE: Your Honor, mixing the two charts a little bit sometimes leaves me a little lost. We have certain end of action timings that are in the US Fish & Wildlife Service proposal, and they are clearly not identical to those that are in --

THE COURT: That is correct. And what I'm going to suggest that you do is that you now reduce to writing the orders that I have pronounced. The court reporter will provide you the transcript. I'd prefer for there to be a joint submission, but if you can't agree on it, then you can submit competing proposed orders. And I'll resolve any differences.

MR. LEE: All right.

THE COURT: All right? I intend for this injunctive



relief to be binding upon the United States Department of the Interior, its Bureau of Reclamation, the State Department of Water Resources, their agents, officers and employees and those acting for, under and in concert with them and anybody in those agencies who has actual notice of this order.

The order is to remain in effect pending entry of final judgment in this case or further order of the Court.

Is there anything further?

MR. LEE: Your Honor, I think we'd like to look at the transcripts and work on them.

THE COURT: You may. And the one other thing I'm going to do is I'm going to ask for the parties to submit proposed findings of fact and conclusions of law that support this judgment that I have pronounced.

MR. LEE: What time frame, sir, are you talking about?

THE COURT: It would be my preference that they obviously be joint. You give me a reasonable time frame. I think that there is concern that the order go into place. But because we will not be starting any of the remedies September 1st, we don't have that level of urgency.

MR. LEE: Okay.

THE COURT: So what is reasonable?

MR. LEE: May we consult just for a moment on the timing?



(Discussion among counsel, not reported.)

MR. LEE: Your Honor, I've had a chance to consult with the United States, with San Luis and Delta-Mendota, with the Farm Bureau and State Water Contractors, and given our delayed vacations, Your Honor, we would like 60 days to get the order -- get the findings of fact and conclusions of law and the orders to you. That should give us time to consult and see whether we can do something joint. If we can't, to prepare alternate orders and findings of facts.

THE COURT: What's the plaintiffs' timetable?

MS. POOLE: Your Honor, we would propose something much shorter than that. We were thinking more in the order of two weeks.

THE COURT: Well, the court reporter is going to need time to produce the transcript. And so she can give us her transcript estimate now, as to what time.

THE REPORTER: I'd need 30 days.

THE COURT: She needs 30 days to produce the transcript.

MS. POOLE: And Your Honor's order regarding the rough transcripts, you'd like us to rely on the finals.

THE COURT: I will if -- I think we should have a final official transcript for the preparation of the judgment. At least the remedial aspect of the judgment that has been announced today. And so, yes, let's do that. And my estimate



is that you at least need 20 days after you have the transcripts in hand. And so that would be 50 days.

For findings and fact and conclusions of law, there's going to have to be an official transcript. So let's make the period 50 days. When is that? October 22nd, 2007.

Is there anything further?

MR. LEE: That's fine with the date, Your Honor.

MS. POOLE: We very much appreciate --

MR. WILKINSON: Thank you, Your Honor.

MS. POOLE: -- the time and effort you've devoted to this, Your Honor.

THE COURT: Thank you very much. Thank the Court staff, please, they're the ones who have had to stay way, way past their hours of operation.

MR. LEE: Thank you.

THE COURT: Everybody have a good weekend. We will stand in recess.

MR. MAYSONETT: Thank you, Your Honor.

MR. WALL: Thank you, Your Honor.

MR. O'HANLON: Thank you, Your Honor.

MR. BUCKLEY: Thank you, Your Honor.

(Off the record.)

THE COURT: I'd should add that the Department of Water of Resources, the Bureau of Reclamation and the Department of the Interior shall be reserved the right on

1 reasonable notice to deviate from the prescriptive remedies,
2 if necessary to protect public health, safety and the human
3 environment.
4 (The proceedings were concluded at 6:11 p.m.)
5
6 I, KAREN L. LOPEZ, Official Reporter, do hereby
7 certify that the foregoing transcript as true and correct.
8
9 DATED:_____ _____
10 KAREN L. LOPEZ
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# Attachment 14-M

# EXHIBIT 14

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**UNITED STATES DISTRICT COURT**
**EASTERN DISTRICT OF CALIFORNIA**

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| NATURAL RESOURCES DEFENSE COUNCIL, CALIFORNIA TROUT, BAYKEEPER & ITS DELTAKEEPER CHAPTER, FRIENDS OF THE RIVER, and THE BAY INSTITUTE, all non-profit organizations,<br><br>Plaintiffs,<br>v.<br><br>DIRK KEMPTHORNE, in his official capacity as Secretary of the Interior, and H. DALE HALL, in his official capacity as Director of the U.S. Fish and Wildlife Service,<br><br>Defendants.<br><br>SAN LUIS & DELTA MENDOTA WATER AUTHORITY, WESTLANDS WATER DISTRICT, CALIFORNIA FARM BUREAU FEDERATION, GLENN-COLUSA IRRIGATION DISTRICT, et al., CALIFORNIA DEPARTMENT OF WATER RESOURCES, STATE WATER CONTRACTORS; and KERN COUNTY WATER AGENCY.<br><br>Intervenors/Defendants. | Case No.: 05-CV-01207 OWW LJO<br><br>**DECLARATION OF KIRK C. RODGERS** |

I, Kirk C. Rodgers, declare as follows:

1. I am the Director of the United States Bureau of Reclamation (Reclamation), Mid-Pacific Region. In my capacity as Regional Director, I have overall responsibility for the various functions of the Mid-Pacific Region, which includes the operations of the Central Valley Project (CVP).

2. Reclamation understands that during the pendency of the reinitiated Section 7 consultations on ongoing CVP/State Water Project (SWP) operations that section 7(d) of the Endangered Species Act (ESA) applies to its actions.

3. As committed to in my declaration of July 13, 2006, Reclamation will not execute long term water service or repayment contracts with the CVP contractors listed in that declaration during the pendency of the Section 7 consultation on ongoing CVP/SWP.

4. As described in my declaration to this Court filed in October, 2006, Reclamation identified several longer term actions that were scheduled to reach approval or implementation during the pendency of the ongoing reinitiated Section 7 consultations. Reclamation will use the process outlined in that declaration to determine if approval or implementation of those actions remain appropriate in light of Reclamation's obligations under Section 7(d), however, Reclamation will not approve or implement the following actions analyzed in the 2005 Biological Opinion issued by the U.S. Fish and Wildlife Service: (1) South Delta Improvements Program, (2) Delta Mendota Canal/California Aqueduct Intertie Program, (3) Lower American River Flow Standards and (4) Long Term Environmental Water Account.

5. In my previous declaration submitted in October, 2006, Reclamation committed to operate Tracy Pumping Plant (now called Jones Pumping Plant) within existing historic levels as a 7(d) measure.

6. In my declaration submitted in October, 2006, Reclamation committed to using its authorities and available funding to implement additional measures during the pendency of the consultation. Reclamation did just that during May and June of this year to implement several actions aimed at reducing entrainment of delta smelt at Jones Pumping Plant. Reclamation held pumping to 850 cfs or one unit at Jones Pumping Plant for approximately three weeks at the end of the Vernalis Adaptive Management Plan pulse flow period. Additionally, Reclamation spent approximately $5.2 million to acquire

35,000 acre feet of water for release on San Joaquin River tributaries to supplement flows on the San Joaquin River and improve Old and Middle River flows. These actions have been explained to this Court in more detail in the declarations filed in this case by Ronald Milligan, Manager of the Central Valley Operations Office. Reclamation is committed to using the authority granted to Reclamation by Congress to take actions that are protective of delta smelt.

I declare under penalty of perjury under the laws of the State of California and the United States, that the foregoing is true and correct.

Dated this 5th day of July, 2007.

Kirk C. Rodgers, Director
Mid- Pacific Region, U.S. Bureau of Reclamation

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**UNITED STATES DISTRICT COURT**
**EASTERN DISTRICT OF CALIFORNIA**

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| PACIFIC COAST FEDERATION OF FISHERMEN'S ASSOCIATIONS/INSTITUTE FOR FISHERIES RESOURCES, THE BAY INSTITUTE, BAYKEEPER AND ITS DELTAKEEPER CHAPTER, CALIFORNIA TROUT, FRIENDS OF THE RIVER, NATURAL RESOURCES DEFENSE COUNCIL, NORTHERN CALIFORNIA COUNCIL OF THE FEDERATION OF FLY FISHERS, and SACRAMENTO RIVER PRESERVATION TRUST, all non-profit organizations; and the WINNEMEM WINTU TRIBE,<br><br>Plaintiffs,<br>vs.<br><br>CARLOS M. GUTIERREZ, in his official capacity as Secretary of Commerce, WILLIAM T. HOGARTH, in his official capacity as Assistant Administrator for Fisheries, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, DIRK KEMPTHORNE, in his official capacity as Secretary of the Interior, and WILLIAM E. RINNE, in his official capacity as Acting Commissioner, United States Bureau of Reclamation,<br><br>Defendants,<br>and<br><br>SAN LUIS & DELTA MENDOTA WATER AUTHORITY, WESTLANDS WATER DISTRICT, CALIFORNIA FARM BUREAU FEDERATION, GLENN-COLUSA IRRIGATION DISTRICT, et al., and STATE WATER CONTRACTORS, et al.<br><br>Intervenors/Defendants. | Case No. 1:06-CV-00245 OWW LJO<br><br>**DECLARATION OF KIRK C. RODGERS** |

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| NATURAL RESOURCES DEFENSE COUNCIL, CALIFORNIA TROUT, BAYKEEPER & ITS DELTAKEEPER CHAPTER, FRIENDS OF THE RIVER, and THE BAY INSTITUTE, all non-profit organizations,<br><br>Plaintiffs,<br><br>v.<br><br>DIRK KEMPTHORNE, in his official capacity as Secretary of the Interior, and H. DALE HALL, in his official capacity as Director of the U.S. Fish and Wildlife Service,<br><br>Defendants.<br><br>SAN LUIS & DELTA MENDOTA WATER AUTHORITY, WESTLANDS WATER DISTRICT, CALIFORNIA FARM BUREAU FEDERATION, GLENN-COLUSA IRRIGATION DISTRICT, et al., CALIFORNIA DEPARTMENT OF WATER RESOURCES, STATE WATER CONTRACTORS; and KERN COUNTY WATER AGENCY.<br><br>Intervenors/Defendants. | Case No.: 05-CV-01207 OWW LJO<br><br>**DECLARATION OF KIRK C. RODGERS** |

I, Kirk C. Rodgers, declare as follows:

1. I am the Director of the United States Bureau of Reclamation (Reclamation), Mid-Pacific Region. In my capacity as Regional Director, I have overall responsibility for the various functions of the Mid-Pacific Region, which includes the operations of the Central Valley Project (CVP).

2. Reclamation understands that during the pendency of the reinitiated consultations on ongoing CVP/State Water Project (SWP) operations that section 7(d) of the Endangered Species Act (ESA) applies to its actions.

3. For this reason, and for the reasons outlined in my declaration of July 13, 2006, Reclamation will not execute long term contracts with the contractors listed in that declaration during the pendency of the Section 7 consultation on ongoing CVP/SWP operations.

4. Reclamation is reviewing all longer term actions associated with CVP/SWP operations[1] that are scheduled to reach the approval or implementation stage during the Section 7 consultation to determine if approval or implementation of each action remains appropriate given the obligations of the ESA. The review of each of these actions will include determinations on (1) whether there is a sufficient analysis of effects on threatened and endangered species to ensure that the action will not jeopardize any listed species, either through the revised Biological Opinions on CVP/SWP operations or project specific Biological Opinions or concurrence letters, and (2) whether the action would constitute an irreversible or irretrievable commitment of resources that would foreclose the formulation or implementation of any reasonable and prudent alternatives.

5. During the pendency of the consultation, Reclamation will operate the Tracy Pumping Plant within recent historic pumping levels. These pumping levels were included in the 2004 Biological Assessment and analyzed in the Biological Opinions.

6. The 2004 Biological Assessment contains conservation measures to benefit species. These conservation measures will continue to be implemented during the pendency of the consultation. One example of a conservation measure included in the Biological Opinions is the Vernalis Adaptive Management Program (VAMP). VAMP is one of the highest priority actions that benefits delta smelt and salmonids, and involves both increased flows and export reductions. Additionally, depending on the water year and the take at the pumps, we may take actions in the winter to reduce entrainment of adult delta smelt. A third example is maintaining fall flows at a level to benefit the salmon using CVPIA section 3406(b)(2) water. As mentioned in the delta smelt section VAMP will be done in April and May with flows and export reductions at the CVP and SWP.

7. In addition to the actions to ensure compliance with the ESA described above, Reclamation is considering actions to supplement the operations described in the project

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[1] These actions would include, but are not limited to, the South Delta Improvements Program Stage 1, Delta Mendota Canal/California Aqueduct Intertie Project, Yuba Accord, Sacramento Valley Water Management Program, the Lower American River Flow Standards and the Long Term Environmental Water Account Program.

description in Reclamation's 2004 Biological Assessment for the Operations Criteria and Plan (OCAP) that will provide benefits for listed species during the pendency of the consultation. These actions will include, but may not be limited to, the actions described below.

**Delta Smelt**

8. Since the discovery of the decline in pelagic organisms in the Bay-Delta, Reclamation has worked with other federal and state agencies to determine the causes for the decline. Reclamation has committed substantial resources and staff to this effort and will continue to do so for as long as necessary.

9. During the pendency of the consultation, Reclamation is prepared to implement additional measures to benefit delta smelt that may be recommended to the extent they are consistent with Reclamation's authority and available funding.

10. Reclamation has the following water assets available at this time to implement recommended actions for the next water year:

    a. 2006 CVPIA section 3406(b)(2) water (b(2) water): Reclamation has banked approximately 195,000 acre feet of unused b(2) water from the 2006 water year to be used in the 2007 water year, consistent with the pilot banking study. Interior has experimented with banking unused b(2) water for the last two water years, in accordance with the revised 2003 policy on implementation of CVPIA section 3406(b)(2). This water may be used for actions for delta smelt as recommended by the FWS,

    b. EWA Purchased Water: Reclamation has a contract to purchase up to 25,000 acre feet of water for EWA during the 2007 water year. Reclamation is in negotiations with other willing sellers to secure potential assets. These assets will be combined with assets acquired by the State of California for the EWA program.

    c. CVPIA section 3406(b)(1), (b)(2), (b)(3): Reclamation will continue to operate consistent with CVPIA section 3406(b)(1), (b)(2), (b)(3). CVPIA Section 3406(b)(1) provides for modification of the CVP operations to meet the fishery

restoration goals of the CVPIA, so long as the operations are not in conflict with the fulfillment of the Secretary's contractual obligations to provide CVP water for other authorized purposes. CVPIA section (b)(2) provides for the dedication of 800,000 acre feet of CVPIA yield for the purposes articulated in that section. Additionally, Interior is currently authorized to acquire water to supplement (b)(2) water, pursuant to Section 3406(b)(3).

**Salmonids**

11. As stated above, the 2004 Biological Assessment contains conservation measures to benefit species which will continue to be implemented during the pendency of the consultation. As an example,

12. In addition to the actions described in the Biological Assessment, Reclamation intends to address salmonid passage issues in the Sacramento River by continuing its environmental review of the Red Bluff Diversion Dam. Reclamation will be recirculating a draft EIS for public comment by the end of this year.

13. The water assets described in paragraph 8 above are also available for actions to benefit salmonids. Reclamation will continue to work with FWS, the National Marine Fisheries Service, the California Department of Water Resources and the California Department of Fish and Game through the Water Operations Management Team to determine the best use of these assets given the needs of the multiple listed species.

I declare under penalty of perjury under the laws of the State of California and the United States, that the foregoing is true and correct.

Kirk C. Rodgers
Director, Mid- Pacific Region, U.S. Bureau of Reclamation

# Attachment 14-N

EXHIBIT 15

# Interagency Ecological Program 2006-2007 Work Plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary

**January 12, 2007**

Prepared by: Chuck Armor (DFG), Randall Baxter (DFG), Rich Breuer (DWR), Mike Chotkowski (USBR), Steve Culberson (CBDA), Marty Gingras (DFG), Bruce Herbold (EPA), Anke Mueller-Solger (DWR), Matt Nobriga (CALFED), Ted Sommer (DWR), and Kelly Souza (DFG)

## Executive Summary

Abundance indices calculated by the Interagency Ecological Program (IEP) through 2005 suggest recent marked declines in numerous pelagic fishes in the upper San Francisco Estuary (the Delta and Suisun Bay). Although several species show evidence of long-term declines, the recent low levels were unexpected given the relatively moderate winter-spring flows of the past several years.

In response to these changes, the IEP formed a Pelagic Organism Decline ("POD") work team to evaluate the potential causes. The product of this effort was a 2005 study to provide insight into the best lines of inquiry for 2006-2007 studies. The major findings through 2005 were synthesized using two conceptual modeling approaches. First, we developed species matrix models. We used the matrix models to examine which stressors (entrainment, toxic effects on fish, toxic effects on fish food items, harmful algal blooms, clam *Corbula* effects on food availability, and disease and parasites) were most likely to be important. Here we use importance to mean either stressors supported by the available data or stressors which could not be ruled out based on the available data. Secondly, we constructed narrative explanations for the recent step decline in abundance of pelagic species in the context of their long term trends or previous patterns. Narratives have been developed for the major components: 1) *previous abundance levels*, which describes how continued low abundance of adults leads to juvenile production; 2) *habitat*, which describes how water quality variables (including contaminants and toxic algal blooms) affect estuarine species; 3) *top-down effects*, which posits that predation and water project entrainment affect mortality rates; and 4) *bottom-up effects*, which focuses on food web interactions in Suisun Bay and the west Delta.

The overall approach for 2006-7 is intended to evaluate and refine the evidence for the conceptual models. To address the matrix models, the study design is based on *temporal*, *spatial* and *species* contrasts for selected fish and zooplankton. For each contrast, the variables to be evaluated include: abundance, growth rate and fecundity; and feeding success, condition factor, parasite load and histopathology (fish only). To the extent possible, these data will be collected simultaneously to help evaluate the relative importance of different stressors. The narrative model, on the other hand, posits linkages among different stressors and their possible pathways to produce the observed declines of more than one species. The work plan elements that are based on the narrative model, therefore, emphasize analyses of the proposed linkages among stressors.

The proposed studies represent an interdisciplinary, multi-agency effort including staff from DFG, DWR, USBR, USEPA, USGS, CBDA, SFSU and UCD. Project components were selected based on their ability to evaluate the conceptual models, and their feasibility in terms of methods, staffing, costs, timing and data availability. The proposed work falls into three general types: 1) an expansion of existing monitoring (five expanded surveys); 2) ongoing studies (17 studies); and 3) new studies (25 studies). None of the work will affect the mandated monitoring currently under performed by IEP. The initial cost estimate for 2007 is approximately $3,260,000 annually.

The program will be run by the existing IEP Project Work Team (Pelagic Organisms Decline – "POD PWT" to develop, direct, review and analyze the results of the effort. The program will yield a range of products and deliverables including management briefs, publications and reports, web-based monitoring data, and presentations at conferences, workshops and meetings.



## Introduction

In the last several years, the abundance indices calculated by the Interagency Ecological Program (IEP) Fall Midwater Trawl survey (FMWT) and Summer Townet Survey (TNS) showed marked declines in numerous pelagic fishes in the upper San Francisco Estuary (the Delta and Suisun Bay) (IEP 2005a,b). The abundance indices for 2002-2004 include record lows for delta smelt and age-0 striped bass and near-record lows for longfin smelt and threadfin shad. In contrast, the San Francisco Bay Study did not show significant declines in its catches of marine/lower estuary species. Based on these findings, the problem appears to be limited to fish dependent on the upper estuary.

While several of these declining species - including longfin smelt and juvenile striped bass have shown evidence of long-term declines - there appears to have been a precipitous "step-change" to very low abundance by at least 2000 (IEP 2005a,b). Moreover, the record or near-record low abundance levels are remarkable in that winter-spring river flows into the San Francisco Estuary were moderate during this period. Many estuarine organisms including longfin smelt and striped bass typically produce poor year classes in dry years (Jassby et al. 1995); delta smelt abundance is generally lowest in very wet or very dry years (Moyle et al. 1992). Thus, we expected the moderate hydrology during the past three years to support modest production.

In response to these changes, the IEP formed a Pelagic Organism Decline ("POD") work team to evaluate the potential causes. The product of this effort was a 2005 work plan, which provided an overview of the problem, a conceptual model, and description of a "screening level" study to examine some of the suspected major causal factors (IEP 2005a). Note that the 2005 work was not designed to "prove" which stressor(s) was responsible for the observed trends. Instead, this effort was intended to provide insight into the best lines of inquiry for the 2006-2007 studies. Highlights of the 2005 results included the following initial results. More details are available in IEP (2005b).

*Pelagic fishes.* 1) In 2005, the highest spring outflow conditions since 2000 failed to improve fish abundance; 2) there was no evidence of a recent decrease in the amount of "physical habitat" for delta smelt or juvenile striped bass; 3) there was no evidence of a recent major decline in apparent growth rates for delta smelt, longfin smelt, or striped bass; 4) in 1999 and 2004, delta smelt in Cache Slough had higher residual growth/condition than other locations; 5) striped bass age-fecundity relationships in 2005 did not differ substantially from relationships developed in the 1970s and 1980s; and 6) otolith analyses indicated that in 1999 delta smelt spawned throughout the upper estuary recruited to the adult population, whereas in 2004, only fish spawned in the Delta recruited.

*Food web/exotic species.* 1) Reanalysis of the zooplankton data revealed that there was no recent step-change in calanoid copepods; however, we are still determining whether regional e.g. Suisun Bay, declines occurred; 2) there has been no recent major decline in chlorophyll *a* (an index of phytoplankton biomass); however, we are still determining whether regional e.g. Suisun Bay, declines occurred; 3)the toxic blue-green alga *Microcystis* was present throughout the Delta at substantially higher levels in summer 2005 than in summer 2004; 4) although there has been a recent expansion in the range of the clam *Corbula*, recent occurrence is comparable to the 1987-

1992 drought; and 5) changes in sediment composition and benthic assemblages occurred estuary-wide in 1999-2000.

*Toxics.* 1) Studies on contaminants found that there have been changes in the patterns of use for herbicides and pyrethroid pesticides. It is plausible, but unclear if these changes pose serious risks for aquatic species; 2) significant acute or chronic toxicity to the amphipod, *Hyalella azteca*, was detected at four out of ten sampling sites, however the cause(s) was not identified; 3) no significant toxicity to the cladoceran, *Ceriodaphnia dubia*, the delta smelt or the juvenile striped bass was observed during the study period; 4) delta smelt are more sensitive to copper than previously reported and are 10-12 times more sensitive than juvenile striped bass; and 5) delta smelt from 2003 and 2005 (limited) showed more liver lesions at two locations representing general regions in Suisun Marsh (near and in Nurse Slough) and the Sacramento River at Cache Slough and the Sacramento Deepwater Ship Channel.

*Water Project Operations.* 1) There have been changes in the input flows to the Delta in recent years, including a slight increase in average Sacramento River flow since 2001 and a substantial reduction in peak San Joaquin flows since 1999. 2) There was no evidence of a recent major change in residence time, consistent with the lack of change in chlorophyll *a*. 3) Increases in the pattern of wintertime salvage are consistent with hydrodynamic changes occurring each winter since 2001. 4) Nonconsumptive water use by Contra Costa and Pittsburg power plants may reach 3200 cfs (both facilities combined). The fish population impacts of these diversions have not been evaluated since the early 1980s, but given their location and the potentially large cooling water flux through them, the impacts could be substantial.

## Conceptual Model

### Initial Conceptual Model

Based on the initial hypothesis that fish abundance declined abruptly by 2002, we developed an initial conceptual model (IEP 2005a). Specifically, we proposed at least three general factors that may have been acting individually or in concert to lower pelagic productivity: 1) toxic effects; 2) exotic species effects; and 3) water project effects (Figure 1). The conceptual model used these categories to illustrate the potential pathways by which pelagic species in the Delta could be affected (Figure 1). For each group of "boxes" shown in the model, one or more examples are provided in italics. The arrows represent the potential mechanisms for changes. Note that not all of the organisms shown in each box are necessarily responsible for each of the mechanisms. Some of the rationale for these components is described below.

Toxins could affect fishes directly or indirectly by reducing lower trophic level quantity or quality. Herbicides could directly affect phytoplankton, zooplankton and fishes, while insecticides are most likely to affect zooplankton and fish. Toxic effects at lower trophic levels may reduce food supply for fishes and/or their invertebrate prey. Blooms of the blue-green alga (cyanobacteria) *Microcystis aeruginosa* have been observed in the Delta since 1999 (Lehman and Waller 2003, Lehman et al. 2005). This species complex often produces toxic metabolites collectively known as microcystins. Microcystins are cancer-causing to humans and wildlife, including fish (Carmichael 1995), and reduce feeding success in zooplankton (Rohrlack et al.



2005). Microcystins have been found in Delta zooplankton and clam tissue and could impact organisms at higher trophic levels through bioaccumulation (Lehman et al. 2005). The switch from organophosphate to pyrethroid pesticides increased substantially through the 1990s (see Oros and Werner report in Attachment A of 2005 POD Synthesis Report). Pyrethroid pesticides have been shown to be less harmful to humans and terrestrial wildlife but more harmful to aquatic organisms. The rising use of organic herbicides and copper-based compounds to control nuisance aquatic weeds and algal blooms in the Delta may also pose a threat to desirable aquatic organisms.

The negative effects of invasive exotic species in the estuary have been well-established. Some notable examples were the substantial declines in lower trophic level productivity that followed the introduction of *Corbula amurensis* (Nichols et al. 1990; Kimmerer and Orsi 1996; Jassby et al. 2002, Kimmerer submitted) and the reduced abundance of native nearshore fishes associated with proliferation of *Egeria densa* and centrarchid fishes along Delta shorelines (Brown and Michniuk in review; Nobriga et al. 2005). At this time, we have limited information about quantitative aspects of the estuarine food web needed to estimate *Corbula* grazing rates or predict whether nearshore and pelagic food webs are coupled in ways relevant to the production of pelagic fishes.

Kimmerer (2002a) showed that water project operations have resulted in lower winter/spring inflow and higher summer inflow to the Delta. As noted previously, the actions by the CALFED implementing agencies have restored some spring inflow, but have also increased summer inflows to meet increasing summer export demands. Winter exports have also increased by about 50% in recent years. These shifts were implemented based on the assumption that it would be more protective to sensitive early life stages of key estuarine fishes and invertebrates. However, it is possible that high export during summer-winter months has unanticipated food web effects by exporting biomass that would otherwise support the estuarine food web. Other possible mechanisms include increased entrainment of fishes during the summer-winter months, or a reduction in habitat quality downstream (e.g. less area of the appropriate salinity). Total annual exports have continued to increase. It is also possible that the total volume diverted on an annual basis influences estuarine productivity (Livingston et al. 1997, Jassby et al. 2002).

## Delta Pelagic Species Conceptual Model

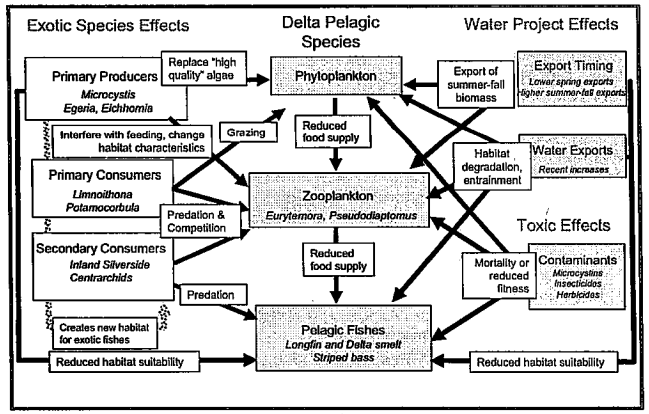



Figure 1. Delta pelagic species conceptual model

**Revision of 2005 Conceptual Model**

We had planned to use the initial conceptual model (Figure 1) as the basis of the synthesis. However, this conceptual model was based on earlier data showing a system-wide decline in calanoid copepods, which a re-examination of the data in 2005 did not support. Moreover, we found that the model did not adequately reflect spatial and temporal variation in the stressors on pelagic organisms. Initial results from 2005 also suggested that some stressors might act independently of the estuarine food-web that was central to our conceptual model. Though the model provided a useful basis to design the 2005 study program, we chose a somewhat different approach for the 2006-2007 effort.

The 2006-2007 models represent an improvement over the 2005 model, but it is important to recognize that there are still potentially numerous limitations (IEP 2005b). Much of the 2005 data is preliminary or unavailable at this writing and has not yet been peer-reviewed, so the new models should be considered equally preliminary. Moreover, we acknowledge that our models may have been influenced by potential biases in the sampling programs. Several changes in the size and distribution of the target species have the potential to change our perceptions of trends in abundances and distributions. This, in turn, has the potential to affect our conceptual models. Finally, it is important to recognize that the recent step decline in pelagic fish species is superimposed over long term declines for several of them and long term relationships of these fish with other environmental factors.



The major findings through 2005 were synthesized in two general ways (IEP 2005b). First, we developed species matrices to examine which stressors were most likely to be important based on the available data or which could not be ruled out because we had no data to base such a conclusion. Secondly, we constructed narrative explanations for the recent step decline in abundance of pelagic species in the context of their long term trends or previous patterns. Note that both types of models were specifically developed for the purposes of designing the work plan for 2006 and beyond—they were not intended to be the basis of setting resource management priorities.

***Matrix Model for Species and Stressors***

Matrix models were developed for the four target fish species (delta smelt, longfin smelt, threadfin shad and juvenile striped bass) to summarize the potential role of various stressors in the recent decline. The matrices depict our current consensus of whether or not each stressor impacted each species-life stage during 2002-2004, possibly influencing the decline. The level of information used to support our consensus is also ranked. Though we attempted to develop information on most of the stressors listed, there are numerous cases where data are unavailable or have not been analyzed. In such instances we indicate no information, but have an expectation that information will be available soon to refine the models. The stressors evaluated are listed below:

- Mismatch of larvae and food. This stressor focuses on the separation of larval fish and food items in time and geographical space. If young fish are not co-located with food, they will starve or have increased vulnerability to predation (Cushing 1990). For the purposes of the matrices, the stressor is considered to apply only to larvae—it is considered separate from fish that can swim strongly enough to search large areas to locate food.

- Reduced habitat space. Amount of open-water habitat as defined by physical and chemical parameters that limit the distribution of species.

- Adverse water movement/transport. Changes in Delta hydrodynamics that direct fish to unsuitable areas due to water project operations. Transport refers to movement of a life stage as influenced by Delta hydrodynamics which can be altered by water project operations (i.e. exports, gate operations, reservoir releases, barriers). Delta hydrodynamics affects transport through its effects on migratory cues, habitat quality or hydrologic resident times. This stressor specifically excludes entrainment, but may include thermal effects of power plant effluent.

- Entrainment. Mortality of pelagic fishes caused by loss to water diversions for exports, in-Delta uses, and power plant cooling.

- Toxic effects on fish. Acute and chronic effects sufficient to increase mortality and/or reduce fecundity of pelagic fishes.

- Toxic effects on fish food items. Acute and chronic effects sufficient to increase mortality and/or reduce fecundity of pelagic fish food items.

- Harmful *Microcystis* blooms. Acute and chronic effects of *Microcystis* sufficient to result in one or more of the following in pelagic fishes: increase mortality; reduce fecundity, reduced feeding; or habitat avoidance.

- *Corbula* effects on food availability. *Corbula* decreases phytoplankton and zooplankton, which is reflected in the production of larger zooplankton, invertebrates or fish especially in early lifestages.

- Disease and parasites. Disease or parasites that result in reduced survival or fecundity of pelagic fishes.

The species matrices are included as Figures 3-7. Annotations for the matrices are provided in Appendix A. Columns represent key times of the year, with reference to the corresponding life stages. The rows describe the relationships between life stages and the major stressors. Within each cell is an idealized "map" containing sub-cells to represent the major regions of the upper estuary (Figure 2). The various regions of the Delta have been described differently by different authors. For aquatic organisms, we believe the tidal nature of the estuary overrides many of the geographic features. Thus, in our discussion of the areas of the Delta, we intentionally use overlapping areas to better account for the fact that water frequently moves from area to area while still bearing in mind that the stressors and processes in different areas are different. This overlap is most pronounced in discussing "Suisun Bay" and the "Northern Delta" (i.e. the blue and green areas in Figure 2). Marine influences, including X2 position can have impacts up the axis of the estuary as far as Decker Island, while significant factors, such as sediment plumes from the Yolo Bypass are at times prominent downstream to at least Chipps Island. Similarly, the San Joaquin River is not representative of a single area's influences but rather the southern limit of Central Delta processes and the northern limit of South Delta processes. Therefore, we have included the San Joaquin River within both areas in our delimitation of the Delta. The actual areas of overlap may also be taken to represent the tidal excursions in each area, such that areas of overlap are much longer in the western regions than in the more upstream locales. Overall, we are concerned with identifying the areas where stressors and processes originate and less concerned with their exact locations of impact.



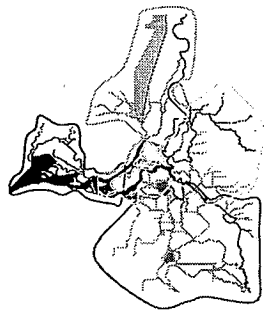


Figure 2. Map of the Delta to identify the regions specified in the matrix.

The geographic boundaries roughly correspond to: Suisun Bay (Suisun Bay, river confluence area downstream of Decker Island and Big Break); Central Delta (South of Rio Vista, North of Franks Tract): North Delta/Lower Sacramento River; South Delta/San Joaquin River (Franks Tract and south/east Delta). The symbols within the "map" are designed to reflect a binary potential for the impact of each stressor (described below) and the degree to which available data support our assertions. Additional details about the logic for each symbol are provided as annotations in Appendix B in 2005 POD Synthesis Report.

Impact

Plausible Impact = The factor (stressor) is likely to have a substantial influence on lifestage survival (*Large Symbol*).

No Likely Impact = The factor (stressor) is unlikely to have a substantial influence on lifestage survival (*Small Symbol*).

Information

Strong = Substantial information exists for directly addressing the stressor influence on the specific lifestage (*Dark Symbol*)

Limited = Either available information or current data analysis is too limited to support strong conclusions regarding stressor) influence on the specific lifestage (*Grey Symbol*).

None = Either information is not available, or no available data have been appropriately analyzed, to address stressor influence on the specific lifestage (*Clear Symbol*).

Figure 3. Legend for Matrix Models

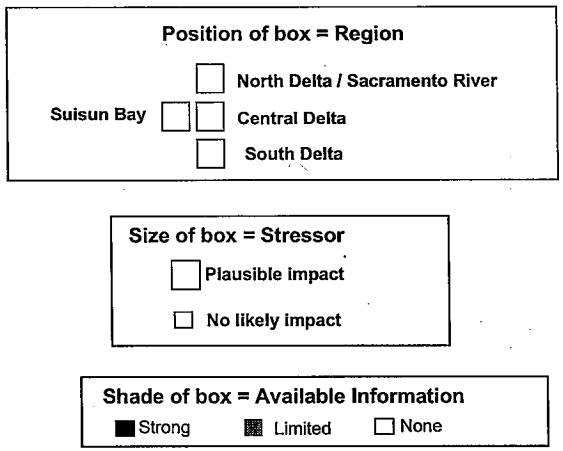





Figure 4. Longfin smelt matrix model

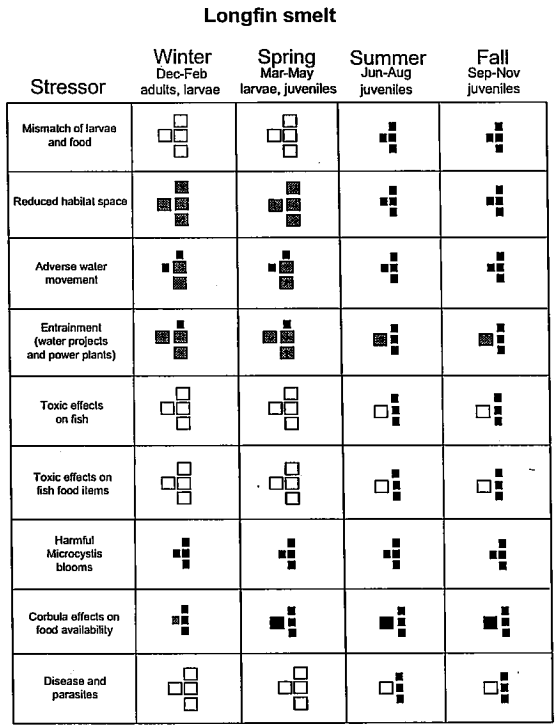


Figure 5. Threadfin Shad matrix model

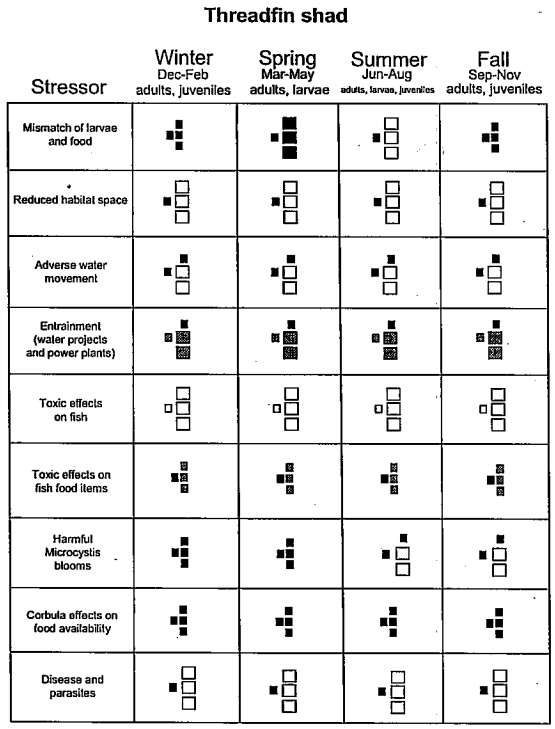





Figure 6. Striped Bass matrix model

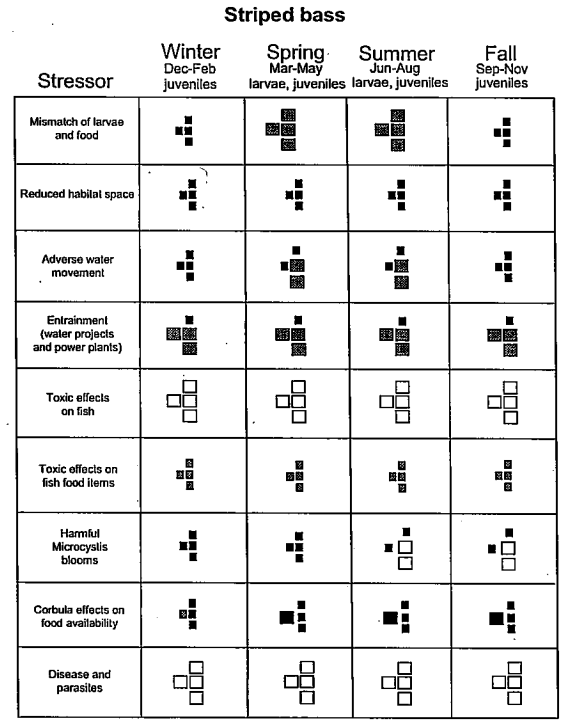
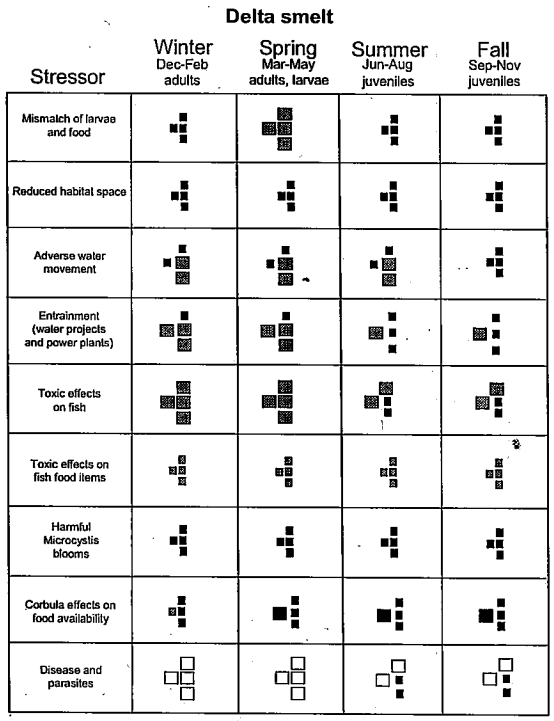


Figure 7. Delta Smelt matrix model






### *Narrative Model*

Guided by available results, we developed a narrative model to describe possible mechanisms by which a combination of long-term and recent changes in the ecosystem could produce the observed declines in catch of pelagic fish species. The model is based on the simple schematic shown in Figure 8. The major components contained in the narrative model are as follows: 1) *prior fish abundance*, which describes how continued low abundance of adults leads to juvenile production; 2) *habitat*, which describes how water quality variables (including contaminants, disease and toxic algal blooms) affect estuarine species; 3) *top-down effects*, which posits that predation and water project entrainment affect mortality rates; and 4) *bottom-up effects*, which focuses on food web interactions in Suisun Bay and the west Delta. These narrative model components are described in detail in the following sections.

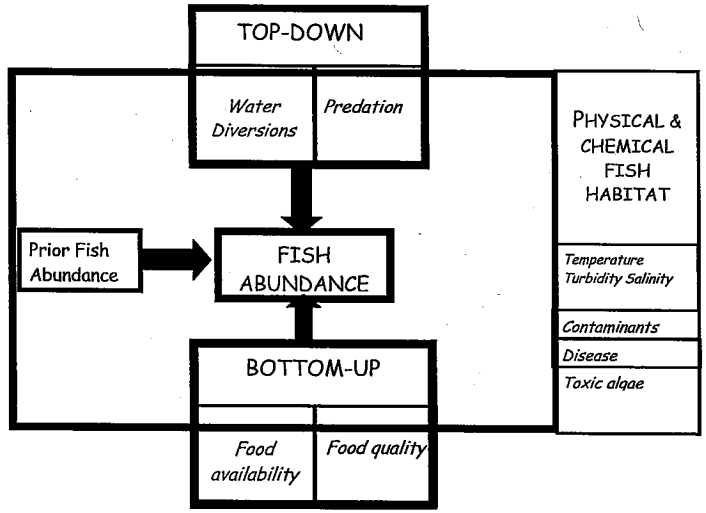



Figure 8: Components of the narrative model for the pelagic fish decline in the upper San Francisco estuary.

**Note that these narrative model components are not exclusive of other explanations for the observed changes in fish abundance, nor are they intended to suggest priorities for resource management.** Instead, they were intended as examples of how the different stressors may be regionally linked. Moreover, no single narrative component can explain the declines of

all four species though both in tandem plausibly could. The narrative models will be developed and refined as data become available. In the meantime, we believe that the two initial narrative models provide a useful basis for the development of more detailed hypotheses and studies for 2006-2007.

*Previous Abundance Narrative*

The relationship between numbers of spawning fish and the numbers of young subsequently produced are known as stock-recruit relationships. Stock-recruit relationships have been described for many species and are a central part of the management of commercially and recreationally fished stocks. Different forms of stock-recruit relationships are possible, including density-independent, density-dependent, and density-vague types. The latter refers to situations where there is not a statistically demonstrable stock-recruit relationship observable in available data. Of particular importance for the POD is that adults are needed to make young, so in any form of a stock-recruit model, there is likely a point at which low adult stock will result in low juvenile stocks even under favorable environmental conditions while the stock 'rebuilds' itself. Currently, the adult striped bass stock is not very low, so the previous abundance narrative does not apply to striped bass. However, it may apply to the other three species. It is not currently known what level of abundance index would represent a "point of no return", or a point of slow return. This is partly due to the density-vague nature of delta smelt stock-recruit relationships (see Bennett 2005).

*Habitat Narrative*

Aquatic habitats are the suites of physical, chemical, and biological factors that species live in (Hayes et al. 1996). The maintenance of appropriate habitat quality is essential to the long-term health of aquatic resources (Rose 2000; Peterson 2003). In our narrative model, a key point is that habitat effects occur on all other components of the model (Figure 8). Hence, changes in habitat can not only affect pelagic fishes, but also their predators and prey. Moreover, we expect that this habitat is especially vulnerable to future climate change.

*Pelagic Fish Habitat:* Habitat for pelagic fishes is water. More specifically, it is water with suitable concentrations of natural physical-chemical properties such as salinity, turbidity, and temperature; suitably low levels of contaminants, and suitably high levels of prey production to support growth. The four POD fishes use a variety of tidally-assisted swimming behaviors to maintain themselves within open-water areas where water quality and food resources are favorable (Bennett et al. 2002). The four POD fishes also distribute themselves differentially along the estuarine salinity gradient (Dege and Brown 2004), so at any point in time, salinity is a major factor affecting these fishes' geographic distributions. Water clarity is also an important factor influencing the distribution of young-of-year striped bass and delta smelt (Nobriga et al. 2005; Feyrer et al. accepted manuscript). Water temperatures are important to spawning windows for the POD fishes, but do not appear to exert strong influence on population distributions during summer-fall.

The San Francisco Estuary is a tidal river estuary (also known as a river-dominated estuary). In tidal river estuaries, habitat quality varies rapidly because the sizes, shapes, and general



suitability of nursery areas change as river flow changes (Stoner et al. 2001; Manderson et al. 2002). In the SFE, pelagic habitat quality is thought to be indexed by changes in the location of the 2 psu isohaline because the abundance of numerous taxa increases when flows into the estuary are high and the 2 psu isohaline is pushed seaward (X2; Jassby et al. 1995). Recent research has shown that X2 is a close surrogate for fall habitat quality for the POD fishes, but only a weak surrogate for summer habitat quality. Recent research has also shown that the *Corbula amurensis* invasion in the late 1980s changed the X2-abundance relationships, at least for longfin smelt (Kimmerer 2002) and young-of-year striped bass (IEP unpublished data). This is strong evidence that the present-day food web responds differently to flow than the pre-Corbula food web did. Food web changes also may have affected delta smelt (Bennett 2005). All of these analyses strongly suggest that a biologic aspect of pelagic fish habitat (food availability) has been degraded. Recent results of POD investigations also show that fall habitat suitability has declined due to increased salinity and water clarity in Suisun Bay and the Delta, respectively.

The IEP monitoring data show a trend toward increasing water clarity in the Delta (Jassby et al. 2002). The most likely reasons for this trend are decreasing sediment supply from the Sacramento River basin (Wright and Schoellhamer 2004) and proliferation of *Egeria densa* (Brazilian waterweed; Brown and Michniuk in press). We do not know whether *Egeria* continues to spread into new areas or whether it has filled all suitable shallow water habitats. In lakes, high densities of *Egeria* and similar plants can mechanically filter suspended sediments from the water column (Scheffer 1999). Increased water clarity may be detrimental to at least two of the POD species, young-of-year striped bass and delta smelt because these species/life stages appear to avoid water that is not very turbid.

In addition to habitat changes from salinity, turbidity and invasive species, contaminants can change ecosystem function and productivity through numerous pathways. The trends in contaminant loadings and their ecosystem effects are not as well understood as the natural water quality and zooplankton trend effects on pelagic fish habitat quality. We are currently evaluating general toxicity and Microcystis toxicity looking both for direct toxic effects on the POD fishes and evaluating indirect contaminant effects such as inhibition of prey zooplankton production.

*Habitat for Other Aquatic Organisms:* Much of the previous discussion about how physical conditions and water quality affects pelagic fishes is also relevant to other aquatic organisms including plankton and the benthos. Particularly for planktonic species, the residence time of water must also be considered. Lower residence time generally results in lower plankton biomass, but also may reduce cumulative entrainment effects. In contrast, higher residence time may result in higher plankton biomass build-up and increased food availability for planktivorous fishes; however, it may also promote high temperatures, invasion by *Egeria*, and nonnative fishes, *Microcystis* blooms, etc., and subject small fishes to increased cumulative entrainment. Recent particle tracking modeling results for the Delta show that San Joaquin River residence times are much lower than residence times in the Sacramento River, indicating differences in habitat conditions along a north-south gradient.

*Climate Change Effects on Habitat:* Climate change may have substantial influences on pelagic habitat in the long-term. There are several mechanisms by which climate change could degrade

habitat quality for one or more POD fishes. First, there has been a trend toward more Sierra precipitation falling as rain. This increases the likelihood of floods and may further change Central Valley hydrographs. Altered hydrographs interfere with pelagic fish reproduction, which is usually tied to historical runoff patterns (Moyle 2002). Second, there is the potential for sea level rise. Sea level rise will increase salinity intrusion unless sufficient freshwater resources are available to repel the seawater. This will shift fish distributions upstream and possibly reduce habitat area for some species. Third, climate change is projected to result in warmer temperatures in Central California. As stated above, water temperatures do not currently have a strong influence on POD fish distributions. However, summer water temperatures throughout the upper estuary are fairly high for delta smelt. The lethal temperature limit for delta smelt is 25°C (Swanson et al. 2000). Median July water temperatures in the upper estuary are typically 20-23°C (IEP unpublished data). If climate change resulted in median temperatures in the upper estuary reaching 25°C, delta smelt would have little chance of maintaining viable populations.

*Top-Down Narrative*

This narrative component proposes that the most recent fish declines can be envisioned as the result of the interactive, top-down influence of two kinds of "predators"; piscivorous fishes, and water diversions. The 'top-down' narrative is predicated on the hypothesis that consumption or removal of fish biomass by piscivores (principally striped bass) and water diversions (SWP/CVP exports; power plant diversions) mattered more after the late 1990s because several bottom-up mechanisms interactively reduced the potential of the low-salinity zone and Delta to produce pelagic fish biomass.

*Predation Effects:* We hypothesize that striped bass predation on pelagic fish biomass had increased in all water year types by the latter 1990s due to an increase in the age-1 and older striped bass population during the 1990s. In the San Francisco estuary, adult striped bass have been at very high population levels in recent years (DFG, unpublished data), potentially exerting an unusually high predation pressure on smaller pelagic fishes.

A change in predation pressure may, in part, be an effect of interactions between biotic and abiotic conditions. Natural, co-evolved piscivore-prey systems typically have an abiotic production phase and a biotic reduction phase each year (e.g., Rodriguez and Lewis 1990). Changing the magnitudes and durations of these cycles greatly alters their outcomes (e.g., Meffe 1984). Generally, the relative stability of the physical environment affects the length of time each phase dominates and thus, the importance of each. Biotic interactions like predation will have stronger community-structuring influence in physically stable systems (e.g., lakes). Historically in the estuary, winter-spring flow variation was the abiotic production phase and the biotic reduction phase probably increased in importance during low-flow periods in summer-fall. Multi-year wet cycles probably increased (and still do) the overall 'abiotic-ness' of the estuary; drought cycles likely increased the estuary's 'biotic-ness' (e.g., Livingston et al. 1997). Our managed system has reduced flow variation much of the time and in some locations more than others. This has probably affected the magnitudes and durations of abiotic and biotic phases (e.g., Nobriga et al. 2005). In other words, reduced flow variability in the estuary may have exacerbated predation effects.



High river flow generally increases fish carrying capacity in the upper estuary (Jassby et al. 1995; Kimmerer 2002). This 'fundamental' relationship has been affected by overbite clams for most of the POD species, but not for all fishes responding to flow (e.g., American shad, splittail; Kimmerer 2002). Thus, because there are more prey fish available in wet years, we hypothesize that flow still increases carrying capacity for piscivorous (age-1 and older) striped bass even though it no longer improves age-0 striped bass carrying capacity. If this is true, the string of wet years between 1993 and 2000 likely allowed the adult striped bass population to rebound even though age-0 production declined. Note that juvenile striped bass also were stocked during this period. We hypothesize that this upsurge of piscivorous striped bass may have interacted with increased entrainment (see below) to reduce POD species abundance. This is analogous to long-term dynamics in cannibalistic fish populations where periods of high adult abundance result in low juvenile production until adult mortality reduces predation pressure on younger cohorts (e.g., Henderson and Corps 1997).

*Entrainment:* Major water diversions in the delta include the SWP and CVP export facilities, power plants, and agricultural diversions. Of the three, the patterns of agricultural diversions are the least likely to have changed during the pelagic fish decline. As a consequence, our narrative focuses on power plant and export effects.

The two power plants of concern are located in the western delta at Antioch and Pittsburgh. Nonconsumptive water use by the power plants may reach 3200 cfs, which may be enough to create a substantial entrainment risk for fishes residing in that region of the estuary. Studies in the late 1970s indicate that losses of pelagic fishes can be very high. The recent effects of the diversions are unknown; however, the distribution of some pelagic fishes including delta smelt is centered near the diversions. There may also be some risk to fishes created by thermal pollution or residual chlorine from antifouling activities. The magnitude of these risks is unknown.

Dramatic increases in winter CVP and SWP salvage occurred contemporaneously with recent declines in several pelagic fish species. These unexpected increases in salvage density coincide with the step decline of pelagic fishes by at least 2000. The changes in export timing following the Bay-Delta Accord also have the potential to increase entrainment of longfin and delta smelt larvae during late winter and early spring and threadfin shad larvae during summer. The ***Winter Adult Entrainment Hypothesis*** posits that these events are causally linked. Evidence for the hypothesis includes the following. Additional details are available in IEP (2005b).

(1) Since at least 2001, there appears to have been a step increase in salvage density of most pelagic fishes.
(2) During the same time period, similar increases in salvage have also been observed for many non-pelagic fishes including centrarchids and inland silverside.
(3) There appears to have been a step decrease in the Fall Midwater Trawl indices of adult delta smelt, threadfin shad, and longfin smelt between 2001 and 2002.
(4) Winter exports from the CVP and SWP have increased since the late 1990s.
(5) Since 2000, San Joaquin River inflow has decreased, while Sacramento River has increased.

Increased winter entrainment of delta smelt, longfin smelt and threadfin shad represents a loss of the pre-spawning adults and all potential progeny. The altered fall-winter hydrodynamics

(salinity intrusion, export to inflow ratios, Old and Middle river flows) also may result in more fish spawning in regions where their larvae are vulnerable to entrainment before protective measures begin in April. This means on a per capita basis loss of each adult fish may be equivalent to the loss of hundreds or even thousands of juveniles later in the year. Entrainment impact specifically affecting adult fishes has the potential to be strong, so we regard finding an explanation for this coincidence a high priority.

The main explanations for why winter salvage densities may have increased since 2001 include: (1) the source of exported water has been changed to an area where more of these fishes occur during the winter; (2) the affected fishes have moved to areas from which exports are drawn; and/or (3) winter exports have increased past a hydrodynamic threshold below which fish were better able to avoid entrainment.

We have only just begun to examine the data on wintertime salvage, but they reveal a consistent pattern across species that corresponds with the period of fish declines. Three main areas of explanation must all be considered. Three main questions need to be considered. Are the recent salvage trends reliable, or the result of data error? Assuming data are correct, why did salvage levels increase? Finally, do increases in salvage result in population-level effects? Some of these factors can be rapidly assessed with data already in hand or that can be gathered in the coming months. Assessing the population impacts will be a difficult task since reliable numbers for the number of fish entrained or in the source population are available. If it can be shown that a large part of the field sampled populations are within the range of entrainment that is probably the most compelling argument for a population level impact of entrainment.

*Bottom-Up Narrative*

Suisun Bay/Marsh has historically been a major rearing habitat for striped bass, delta smelt and longfin smelt (Stevens and Miller 1983; Steven et al. 1985; Moyle et al. 1992; Matern et al. 2002). The marshes and other adjacent shallow habitats are also used by threadfin shad (Matern et al. 2002; Nobriga et al. 2005). Pelagic productivity was reduced and trophic linkages were altered in Suisun Bay coincident with the invasion of the clam *Corbula amurensis* (Kimmerer and Orsi 1996; Jassby et al 2002, Feyrer et al. 2003; Kimmerer submitted manuscript). The ***bottom-up hypothesis*** posits that, particularly in drier years, *Corbula* depresses phytoplankton and zooplankton production in Suisun Bay, resulting in decreased availability of food for larval and juvenile striped bass, longfin smelt, and delta smelt. In addition to changes in food availability, changes in food quality due to shifts in phytoplankton and zooplankton species composition may also impact pelagic fish species. Evidence for the hypothesis includes the following.

1. Pelagic productivity in the upper San Francisco estuary is poor relative to other estuaries.
2. Phytoplankton densities and productivity are especially low in the Suisun region.
    - There has been a significant long-term decline in phytoplankton (chlorophyll a) to very low levels in the Suisun region and the lower Delta, with no significant recovery (but also no further declines) over the most recent decade (Jassby et al 2002, Jassby et al in prep.).



    - In contrast, phytoplankton did not decline significantly at the upstream Delta monitoring stations and actually significantly increased at the southern-most Delta monitoring stations over the last decade.
3. Phytoplankton species composition has changed more in the Suisun region than elsewhere.
    - Coincident with changes in phytoplankton abundance in the upper estuary, there were also shifts in phytoplankton species composition from more diatom to more flagellate dominated communities (Lehman 1996).
    - This shift was more pronounced in the Suisun region than elsewhere (Jassby et al. in prep).
4. The Suisun region experienced dramatic changes in zooplankton densities and composition.
    - The Suisun region experienced more pervasive long-term declines in the densities of three calanoid copepod species (*Eurytemora affinis, Sinocalanus doerri,* and *Pseudodiaptomus forbesi*) than the Delta (Mueller-Solger et al in prep.). These zooplankton species are important food organisms for pelagic fishes.
    - *P. forbesi* continued to decline in the Suisun and confluence regions over the last decade, while its numbers increased in the southern Delta. These trends may be related to increasing recruitment failure and mortality in the Suisun region due to inadequate food supplies, *Corbula* predation on copepod nauplii, and insufficient replenishment from more productive upstream regions (Durand et al in prep, Kimmerer et al in prep, Mueller-Solger et al in prep).
    - Coincident with the decline in *P. forbesi* abundance in the Suisun region, densities of a more recent invader, the cyclopoid copepod *Limnoithona tetraspina* significantly increased in the Suisun region. It is now the most abundant copepod species in the Suisun and confluence region, but does not occur in the freshwater upper Delta. (Kimmerer et al in prep, Mueller-Solger et al in prep.) This zooplankton species is thought to be inferior food for pelagic fishes including delta smelt.
    - *Acartiella sinensis*, a calanoid copepod species that invaded at the same time as *L. tetraspina,* also reached considerable densities in the Suisun region over the last decade, but not in the upper Delta. Its suitability as food for pelagic fish species remains unclear.
5. Benthic grazing may be a major mechanism for both the long-term and recent changes in the Suisun food web.
    - *Corbula* abundance and distribution in the Suisun region during 2001-2004 was higher than during the 1995-1999 wet period but similar to the 1987-1992 drought (IEP 2005, Vayssieres et al in prep.).
    - There is evidence that benthic changes have major effects on the pelagic food web and fishes (Kimmerer 2002).

5. Indicators of growth and condition support the hypothesis that there is food limitation in pelagic fishes in the Suisun region (IEP 2005).
    - In 1999 and 2004, residual delta smelt growth was low from the Sacramento-San Joaquin confluence through Suisun Bay relative to other parts of the system.
    - In 2005, delta smelt collected from the Sacramento-San Joaquin confluence and Suisun Bay had high incidence of liver glycogen depletion.
    - In 2003 and 2004, striped bass condition factor decreased in a seaward direction from the delta to the bay.

6. There is less evidence for other types of habitat changes in Suisun Bay (IEP 2005).

- Suisun Bay ambient water bioassays in the summer of 2005 were not toxic to *Hyalella azteca, Ceriodaphnia*, juvenile striped bass, or delta smelt.
- *Microcystis* biomass was low in the Suisun Bay region in the summer of 2004 and 2005.

Thus far, there is little evidence that the unusually poor growth rates, health, and condition of fishes in the Suisun Bay region is due to the effects of toxic contaminants or other adverse chemical or physical habitat conditions. Therefore, our working hypothesis is that the poor fish growth and condition in this region are due to food limitation. If fishes are food limited in Suisun Bay during larval and/or juvenile development, then we would expect greater cumulative predation mortality, higher disease incidence, and consequently poorer abundance indices at later times. Slower growth rates might also distort trawl abundance indices if large numbers of fish do not grow large enough to be sampled efficiently by annual surveys.

Note that there are some inconsistencies that make this hypothesis unlikely as a single mechanism for the recent pelagic organism decline. Specifically, it is unclear why there has been a substantial recent decline in some Suisun Bay calanoid copepod species, but not in phytoplankton chlorophyll *a* concentration. Second, recent *Corbula* levels are not unprecedented; they are similar to those found during the 1987-92 drought years, so it is unclear if and why benthic grazing would have a greater effect on the Suisun Bay food web during the POD years than during the earlier drought years. It is possible that shifts in phytoplankton and zooplankton community composition and perhaps related changes in the microbial food web in the Suisun region could provide a more consistent mechanism

## Study Approach

The overall approach recommended by the POD PWT in 2005 was a "triage" model to better define the degree to which toxics, exotic species and water project operations may be responsible individually, in sequence, or in concert for the apparent long-term fish abundance declines and step-changes. Based on the work in 2005 and on previous information, the following represents the proposed approach for 2006-2007. A key difference is that the work is based on entirely different conceptual models (see previous section). In addition, we have developed a more integrated strategy to evaluate contaminant effects, an issue that has not been evaluated extensively by IEP or the 2005 POD effort.

### Approach to Address Matrix Models

Many of the studies described in the next section are designed to address questions arising from the matrix models. Much of the rationale for the study design is based on *temporal*, *spatial* and *species* contrasts for selected fish and zooplankton. For each contrast, the variables to be evaluated include: abundance, growth rate and fecundity; and feeding success, condition factor, parasite load and histopathology (fish only).

*Temporal Contrasts.* Temporal contrasts will be made seasonally and interannually. Analyses of monitoring data and additional samples will identify if there are specific times of the year in



which stressors are most pronounced. To the extent possible, these results will be contrasted with historical data or samples to determine if current observations are consistent with earlier years. For example, the hydrology in 2005 provided an excellent opportunity for a "natural experiment"—flow conditions were consistently high throughout the spring, which typically results in good abundance levels for many pelagic species (Jassby et al. 1995). Kimmerer (2002b) updated analyses that suggest these relationships have remained reasonably consistent through 2000, despite the invasion of the clam *Corbula*. As noted previously, pelagic fishes did not increase substantially in 2005, so we have more confidence that the apparent step change is real.

Working Hypotheses for 2006-2007:
- The response of pelagic species to flow will continue to deviate from relationships with abundance developed prior to the recent step change.
- Stressor effects have increased relative to historical data.

*Spatial Contrasts*: Monitoring data and new samples will be thoroughly evaluated to determine whether there is a specific region(s) of the estuary where stressor effects are strongest and to the extent possible, whether regional effects have changed in recent years. For example, one of the key spatial contrasts is whether fish and zooplankton show similar responses (e.g. growth, survival, fecundity, toxicological indicators) in the Delta and Napa River because some key stressors (*Microcystis*, waterweed treatment compounds) appear to be largely absent from the latter.

Working Hypotheses for 2006-2007:
- Pelagic species will show the strongest responses to stressors in specific regions of the estuary.
- Stressor effects have increased in specific regions of the estuary relative to historical data.

*Species Contrasts*: Fish species (delta smelt, striped bass, longfin smelt, threadfin shad and inland silverside) will be the focus of the 2006-2007 effort. These species were selected because they form convenient contrasts: The first four are declining in abundance – striped bass and longfin smelt over the long-term, delta smelt and threadfin shad more recently, while the last is increasing. Our rationale is that contrasts among these species will help to clarify the relative importance of different stressors.

Working Hypotheses for 2006-2007:
- The more recent invaders (inland silverside) will show less response to stressors.
- Nearshore fishes (e.g. inland silverside) will show less response to stressors.

### Approach to Address the Narrative Model

The matrix models highlight the stressors in each season and each geographical area that might affect each species. Work based on the matrix models ask fundamentally qualitative questions; is the stressor likely to have an effect? The narrative model posits linkages among different stressors and their possible pathways to produce the observed declines of more than one species.

The work plan elements that are based on the narrative model, therefore, emphasize analyses of the proposed linkages among stressors. Questions addressed by the narrative model are much more quantitative; to what degree do these stressors affect the species of concern? The basic narratives comprising the model are shown in Figure 8. The approach to address each narrative component is described below. Table 1 provides a coded list of studies that will be used to address each of the narratives. Finally, we include a synthesis section to summarize the studies that will be used to integrate the effects of each of the model components, thereby addressing the ultimate question in the POD studies--what is the population level effect of each of the stressors?

An important point regarding the narrative model approach is that each of the component narratives should be considered as an integrated program, not as "stand-alone" programs. As one example, much of the data on abundance and other population measures (e.g. growth, origin) collected in the first narrative model element, "Previous Abundance and Current Abundance", will be used as part of the evaluations in all of the other narrative model elements. Similarly, the "Habitat" narrative element will collect data on hydrology, water quality, and other habitat measures that will be used as the basis for analysis by all of the other narrative elements.

*Previous Abundance and Current Abundance*

This narrative element will collect a variety of monitoring data that can be used by all of the other narrative elements, and the synthesis efforts. However, the data will also be used specifically to evaluate the role of previous abundance (i.e. adult stock) play in long-term population dynamics of the POD fishes. The major tasks are as follows: Two major types of data will be collected: 1) trends in fish abundance and population size; and 2) trends in other measures of population status.

Trends in fish abundance and population size will be evaluated using the following study elements:

- Summer Townet Survey (2007-007; DFG). This component provides a juvenile abundance index for striped bass and delta smelt.
- Fall Midwater Trawl Survey (2007-003; DFG). This component provides a juvenile abundance index for striped bass and longfin smelt, and adult abundance estimates for delta smelt and threadfin shad.
- Gear Efficiency Studies (2007-086; DFG). This element will explore potential limitations to interpretation of fisheries monitoring datasets that may limit their ability to be used for population abundance estimates.
- Estimation of Pelagic Fish Population Sizes (2007-043; DFG/USFWS-Ken Newman). This component will explore the ability of current IEP data to develop population abundance estimates for POD fishes.
- Threadfin Shad Data Analysis and Population Dynamics (2007-039; DWR). This component will take the first comprehensive look at long-term datasets for threadfin shad.
- Trends in fish biomass (2007-119; DWR). Building on previous estimates by Wim Kimmerer (SFSU), this component will use population data to develop regional estimates of trends in fish biomass.



- Historical population dynamics (2007-084; USBR). Consultant Bryan Manly will continue work with USGS staff on historical population dynamics to assess temporal and special trends in different fish species and communities.

A variety of other studies will collect fish for the evaluation of other useful measures of population health and status:

- Directed Field Collections (2007-089; DFG). This component provides additional fish samples for the elements listed below on an as-needed basis.
- Evaluation of Apparent Growth Rates (2007-051; DFG). This component provides a long-term time series of plausible growth trajectories for POD fishes.
- Delta Smelt Otolith Microchemistry (2007-060 and 2007-040; UCD). This component provides an empirical check of delta smelt growth rates in recent years.
- Delta Smelt Histopathology Investigations (2007-061; UCD). This component provides a basic health assessment for delta smelt to evaluate mechanisms for growth rate changes.
- Striped Bass Health Investigations (2007-042; UCD). This component provides a basic health assessment for young-of-year striped bass to evaluate mechanisms for growth rate changes.
- Disease as a Factor in the POD (2007-036; FWS). FWS will conduct surveys of disease occurrence in delta fishes.

*Habitat Effects*

This narrative element will collect a variety of physical, chemical and biological data that can be used by all of the other narrative elements, and the synthesis efforts. The data will also be used specifically to evaluate several habitat-specific questions: 1) what are the trends in basic habitat variables? 2) what changes in habitat quantity and quality affect pelagic fishes? 3) what changes in habitat quantity and quality affect other organisms in the estuary? 4) how do toxics, disease and toxic algal blooms affect the previous two groups of organisms? Although the last question is essentially a subset of the second and third, we have chose to include it separately because we have relatively little baseline information on this issue as compared to other water quality measurements.

*Trends in basic habitat variables:* General patterns in estuarine habitat will be assessed with water quality and hydrological data.

- Environmental Monitoring Program (2007-072; DWR). This component provides simultaneous water quality and relevant non-fish data (e.g., zooplankton, Corbula) throughout the year.
- Changes in Water Project Operations (2007-097; USGS). One result of this "data mining" effort will be to describe trends in the hydrology of the delta and its tributaries.
- CASCADE (2007-081; USGS) The potential effects of climate change on estuarine habitat will be addressed through a computational assessment of scenarios.

*Effects of changes in habitat quantity and quality on pelagic fishes:* The goal of this series of studies is to characterize trends in pelagic fish habitat suitability. We will pursue the following

questions: Has the surface area of suitable habitat changed for one or more of the POD species? Does interannual variation in estuarine hydrology influence the spatial extent of pelagic fish habitat? What factors have affected the spatial extent of pelagic fish habitat? What are the trends in physical habitat area in the Delta versus Suisun Bay? Do the previous findings differ when the availability of zooplankton prey are factored into the analysis? How do flow changes alter the size and/or shape of pelagic fish habitat zones? Two main study elements are proposed:

- Evaluation of Changes in Pelagic Fish Habitat Quality using the IEP Long-Term Monitoring Data (2007-066; DWR). This element is a continuation of earlier work by DWR based on analyses of Fall Midwater Trawl and Summer Townet Survey data.
- Spatial Analysis of Habitat and Fish Co-occurrence (2007-120; TBD). The goal of this study element is to use GIS methods to evaluate short time-scale changes in habitat shape in relation to fish distribution and life history needs.

*Effects of habitat quantity and quality on other organisms:* The approach to evaluating the effects of habitat on other organisms involves several elements intended to improve our understanding of large-scale ecosystem changes.

- Evaluation of Changes in Pelagic Fish Habitat Quality using the IEP Long-Term Monitoring Data (2007-066; DWR). While this study focuses on fish effects (see above), the investigation will also include similar analyses for key zooplankton species, and to the extent possible, for Corbula.
- Corbula Salinity Tolerance and Grazing Rates (2007-076; SFSU). In a new study element, SFSU will use laboratory methods to analyze Corbula salinity tolerances, and the effect of salinity on clam grazing rates.
- Submerged Aquatic Vegetation (SAV) abundance and distribution (2007-102; UCD/USGS). The negative effect of SAV on native fishes in the Delta is now well-established in the literature (Grimaldo et al. 2004; Nobriga et al. 2005; Brown and Michniuk in press). Thus, our primary SAV study question is: Is the distribution of SAV continuing to expand through the Delta? The importance of turbidity as a necessary component of young striped bass and delta smelt habitat also is now recognized, so a second study question is: How much does SAV contribute to increased water clarity in the Delta?
- Delta and Suisun Bay Particle Tracking Investigations (2007-031; DWR). Residence time represents a key variable affecting planktonic organisms. This component will use the DWR DSM-2 model and its particle tracking model to evaluate trends in modeled particle transit times through the Delta. We expect this element to provide data pertinent to larval transport and entrainment of prey resources originating in the San Joaquin River.

*Effects of contaminants, disease, and toxic algal blooms:* The 2005 findings did not clearly support or eliminate contaminants as a possible significant cause or additive stressor in the POD. The toxicity work in 2005 was limited due to spatial and temporal restrictions on the sampling and analyses. The focus on pyrethroids and aquatic herbicides investigations was based on the overall hypothesis of a step decline coinciding with a major change in contaminant loading due to a change in land use coinciding with the decline. Research into these two areas was in the form of white papers, and did not include field level work. Though aquatic toxicity to *Hyalella*



was observed in the Delta in 2005, there was little evidence from the review of aquatic herbicide application data indicating this is a source of toxicity.

Although there is a relative lack of information about contaminant effects, we recognized the need to develop an integrated strategy to make the best use of the available resources for contaminant studies. To summarize briefly, the approach for 2006-2007 is to expand the toxicology testing to additional sites over a greater period of time. Toxicity tests will be run on *Hyalella*, since this organism has established TIE procedures. Delta smelt and striped bass will be tested with water samples from some of the sites: if toxicity is observed, analyses will advance to TIE procedures to try and isolate the compound. Fish exhibiting toxicity will be submitted for histopathology to be compared with hatchery fish to characterize organ effects. These results will provide a useful comparison with field and archived fish samples that would be analyzed for histopathology. Additional information about potential toxic effects will be gleaned from histopathological analyses of recent and archived fish samples collected from the field. Biomarkers may also be used to help identify specific causes, although more work is needed to identify the most appropriate assays. Moreover, related studies on trends in contaminant use and *Microcystis* bloom location and toxicity will help to illuminate the mechanisms responsible for observed effects.

The components of the contaminant approach are discussed below, with additional detail in the Study Components section. The relationships among these components are shown below in Figure 9.

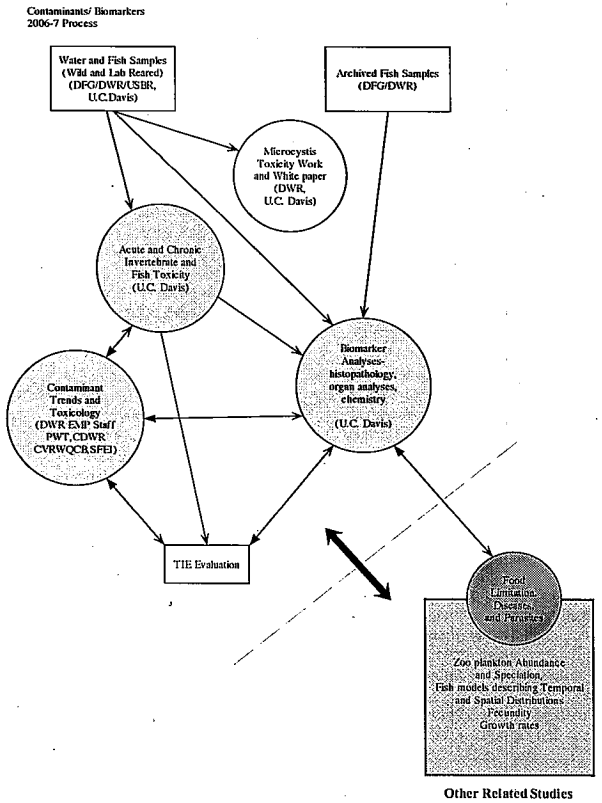



Figure 9. Relationship between components of the POD contaminant investigations.



*Water and Fish Samples:* Work in 2006-07 will consist of a spatially and temporally expanded sampling for toxicity testing program. As part of this effort, Directed Field Collections (2007-089; DFG) will follow the 2005 pilot program, and additional sites will be sampled in accordance with the prevalent distribution patterns of fish species of concern. A subset of these samples will also be used for *Microcystis* studies. Additional analyses will be conducted using archived samples of fish held by DFG (delta smelt) and UCD (striped bass).

*Acute and Chronic Invertebrate and Fish Toxicity Tests/TIE Process:* As noted above, the 2006-2007 toxicity work includes a substantial expansion of the 2005 effort (2007-063; UCD). The indigenous amphipod species, *Hyalella azteca*, will be used for routine toxicity testing throughout the year. This species is resident in the Delta, sensitive to contaminants, and routinely used in toxicity testing programs throughout the Nation. Moreover, it can be used to identify the causative agents of toxicity through Toxicity Identification Evaluation (TIE) procedures. If toxicity is observed at a site through initial screening, TIEs will be initiated immediately. Adequate quantities of water will be collected to proceed with TIEs in case toxicity is observed.

Two fish species of concern (delta smelt and striped bass) will be used to test water samples from selected Delta sites, from larval to juvenile stages during periods when the respective life stages are rearing in the Delta. Fish from these tests will be preserved for biomarker and histopathological analyses. These laboratory tests will identify sites that are acutely toxic to larval/juvenile stages of delta smelt and striped bass, and help differentiate the effects of toxic contaminants from the effects of food depletion (fish will be fed during the laboratory trials), and natural stressors such as water temperature and/or oxygen depletion (laboratory tests are performed at constant temperature and water is oxygenated).

*Histopathology/ Biomarkers:* Histopathological analysis of fish tissues can identify a variety of tissue lesions resulting from exposure to environmental stressors such as contaminants, disease and food limitation. Histopathological lesions often manifest themselves over longer periods of time, and therefore integrate the effects of multiple stressors. It is a useful tool to identify affected organs and can help identify certain groups of contaminants with known mechanism of action (e.g. carcinogens, endocrine disruptors) and target organs (e.g. liver, gonads). Histopathologic studies therefore play an important role in directing and focusing special studies.

The main study elements include POD studies 2007-042 and 2007-061 (UCD), and 2007-036 (FWS). Work in 2006-07 will focus on the examination of fish exposed to water samples or collected from sites where: 1) 2005 results indicated that fish were affected by environmental stressors; 2) where invertebrate toxicity tests indicate the presence of toxic compounds. Lesions in fish from laboratory studies should be compared to lesions observed in fish from field sites, but keeping in mind that actual exposure duration may differ between laboratory-exposed and field-collected fish. Additionally, wild fish may be exposed to natural stressors (water temperature, oxygen levels, and food depletion). IEP staff also will collaborate with EPA staff on a pilot endocrine disruptor study (2007-112).

Additional analyses may be conducted with biomarkers, the molecular, biochemical, physiological and histological changes inside an organism which are indicative of exposure to and/or the effects of environmental stressors (2007-121; DWR). For the POD program, it is important to identify and apply biomarkers that can be applied to the fish species of concern, and help differentiate and quantify stressor groups. Not all biomarkers that are presently being explored in research labs fulfill these requirements, and careful consideration should be given to a work plan for future POD work involving biomarkers. A "Fish Biomarker Task Force" consisting of experts in this field could provide state-of-the-art information on biomarkers. This task force should examine and describe 1) available biomarkers according to a number of criteria including specificity and cost; 2) identify which biomarkers are applicable to Delta fish species of concern and what information they can provide; 3) identify research objectives and timelines for developing specific biomarker tools for Delta fish species of concern.

*Microcystis aeruginosa Bloom Biomass and Toxicity:* Field surveys will be conducted to measure *Microcystis aeruginosa* bloom biomass and toxicity (2007-079; DWR). The 2006 surveys will build on the 2004-2005 survey and be closely coordinated with the fish surveys (Summer Townet Survey and Fall Midwater Trawl) and toxicity assays. Sample collection at fish survey stations will help elucidate the link between *Microcystis* biomass and toxicity and its direct effect on zooplankton and fish. Zooplankton, benthos, and fish toxicity will be evaluated based on microcystin content in whole animal (zooplankton and benthic) or liver and muscle tissue (fish). Animals for these analyses will be collected during fish surveys.

*Top-Down Effects*

*Predation:* The predation portion of the top-down study approach will focus on two major questions: 1) what are the status and trends of the major predators? and 2) what are the effects of changing predation pressure? The first question will be examined using the following suite of studies:

- Status and Trends of Predators in the Delta (2007-118; DFG). Several IEP fish surveys will be analyzed to evaluate the trends in predators, particularly adult striped bass, and largemouth bass. Because most surveys do not effectively sample littoral communities or subadult stages of striped bass, the effort will include exploratory analyses of SWP/CVP salvage, FWS beach seine, and delta bass fishery CPUE data.
- Data from standard Peterson methods will be used to update adult striped bass population estimates for the estuary (2007-116, DFG).

Evaluation of the effects of predation of fish communities is expected to be a more complicated effort, involving some methods that have not traditionally been used for IEP studies.

- Modeling Striped Bass Predation in the Delta (2007-115; DWR). Population estimates developed from the first question will be used as the basis for a bioenergetic model (Fish Bioenergetics 3.0) that will evaluate trends in predation pressure in the delta. The general approach will be to combine age-specific data on growth and abundance of striped bass with bioenergetics modeling to estimate the consumption demand of the striped bass population through time. We will try similar analyses for largemouth bass if sufficient population age structure and growth data are available.
- Modeling of Predator Population Dynamics (2007-116; DFG). Population estimates from the previous study element will be used to model compensatory population mechanisms in the striped bass population. Specifically, the model will examine the likelihood that the present high abundance of adult bass may suppress earlier life stages.



*Entrainment and other Facility Impacts:* Our overall approach to address the entrainment hypothesis is to focus on the following three the major questions: 1) are the salvage trends valid, or are they an artifact of data error or changes in fish facility operations? 2) assuming that the data are valid, what is the mechanism for the increase in winter salvage? 3) what are the effects of power plant diversions on pelagic fishes.

The study approach includes two studies to address the first question, salvage data quality. Some of these factors can be rapidly assessed with data already in hand or that can be gathered in the coming months.

- Fish Facility History (2007-107; USBR and DFG). One component of this study element will evaluate whether changes that have occurred at the state and federal fish facilities since 1956 have substantially impacted the reported number of salvaged fish
- South Delta Studies (2007-015, -016, and -17; DWR and USGS): The South Delta studies will include a component to examine whether the salvage data are consistent between the SWP and CVP facilities, and whether the salvage changes occurred in winter rather than other months. The logic is that if both observations are true, then it is unlikely that the observed increases in winter salvage are invalid.

To evaluate the second question (Why Did Salvage Increase?), we have identified three primary mechanisms (1) the source of exported water has been changed to an area (e.g. west Delta) where more of these fishes occur during the winter; (2) the affected fishes have moved to areas from which exports are drawn; and/or 3) winter exports have increased past a hydrodynamic threshold below which fish were better able to avoid entrainment. With regard to the second mechanism, a shift in distribution may have occurred because south Delta habitat conditions were attractive (e.g. food), or because habitat conditions deteriorated in some regions of the Delta (e.g. contaminants, toxic algae). By analyzing these potential mechanisms at local and region scales, we hope to differentiate the major pathway(s).

- South Delta Hydrodynamic Effects (2007-015, 2007-016, and 2007-017; DWR and USGS). A major focus of the south Delta studies is to determine the effect of hydrodynamics and physio-chemical variables near the SWP on fish behavior and entrainment during relatively short time scale (i.e., hours and days) events.
- Particle Tracking Modeling (2007-031; DWR, USGS and SFSU). Particle tracking using the model DSM2 will be used to evaluate the entrainment risk for different export/inflow scenarios and historical conditions. An additional task will be to model adult delta smelt migratory "behaviors" to evaluate potential entrainment risk during late fall and early winter.

- Changes in Water Project Operations (2007-068; USGS). One result of this "data mining" effort will be to describe any recent changes in water project operations that may have influenced entrainment rates.
- Statistical Effects of Environmental Conditions on Salvage (2007-084; USBR). Consultant Bryan Manly's work USGS staff on historical population dynamics will include statistical analyses of factors affecting entrainment rates.
- Regional indicators of habitat quality, described in detail in earlier sections on Prior Abundance and Habitat. Examples include:
  -Regional comparisons of fish health, growth and origin (2007-060, -061, -062, -018, -036, -121; UCD, DFG, FWS). These studies are designed to evaluate the origin of fish in the south Delta, and whether they show different health, growth or condition than other regions. This should allow us to determine whether there is evidence that environmental factors made fish more vulnerable to entrainment.
  -Regional comparisons of toxicity (2007-063; UCD). Regional toxicity testing will allow us to determine whether water toxicity was different in the south Delta than other areas.
  -Microcystis studies (2007-079; DWR, UCD). Regional sampling will evaluate whether toxic algal blooms were more prevalent in the south Delta than in other regions.

Our study approach to address the third question, the extent of power plant impacts, will be at a much more fundamental level than for the SWP and CVP. Because there have not been detailed studies on power plant entrainment since 1979, much of the focus of this study element will be to collect basic information about species loss, abundance and time. These issues will be addressed in a single study element, "Investigation of power plant impacts" (2007-087; DWR).

*Bottom-Up Effects*

The approach for to address the bottom-up narrative will focus on factors that may be disrupting the food web for pelagic fishes. Much of the emphasis will be on the greater Suisun Bay region, where it appears that pelagic productivity was reduced following the invasion of the clam *Corbula amurensis*. The major study questions to be addressed are: 1) What are the trends in plankton? 2) What factors influence food availability for pelagic fishes? 3) Are there regional or temporal differences in food quality for pelagic fishes?

Studies in support of the first question will be a continuation of work initiated in 2005. These include the following:

- Trends in Delta Phytoplankton. (2007-045; UCD). This UCD-study will evaluate long-term patterns and trends in phytoplankton production and biomass and other water quality variables in different Delta subregions.
- Zooplankton Trends (2007-072; DWR). As part of analyses for the IEP Environmental Monitoring Program, DWR staff will continue analyses of the zooplankton database to evaluate long-term and regional trends in zooplankton community structure.
- Zooplankton Fecundity and Population Structure (2007-044; SFSU). This new POD element will evaluate whether there are changes in zooplankton fecundity and population structure that may have influenced the pelagic food web.



The second question, food availability, will be addressed by evaluating food web linkages, particularly benthic effects. Several new studies are included.

- Food Web Disruption (2007-082; SFSU). In this CALFED-funded POD element, SFSU will lead an effort to evaluate how the food web has changed in recent years.
- Benthic Biomass and Abundance (2007-065; DWR). This POD element will continue to develop estimates of benthic abundance and biomass.
- Fish Diet and Condition (2007-062; DFG). To help develop an understanding of pelagic fish feeding ecology, DFG will continue with diet analyses of the primary pelagic fishes.
- Food Match/Mismatch (2007-122; DFG). This POD study element will use larval fish and zooplankton data from the 20 mm trawl survey to evaluate whether there is a mismatch between the locations of young pelagic fish and their zooplankton prey.

In addition to food quantity, there is substantial evidence in the literature that food quality can also play an important role in growth and survival of pelagic fishes. Because IEP has little experience with this issue, we are proposing an exploratory effort to identify whether food quality is likely to be an issue in the San Francisco estuary. As a first step, we intend to identify biomarkers that have been found to indicate the nutritional quality of fish diets. This will be combined with identification of biomarkers for contaminant exposure.

- Biomarkers of Contaminant Exposure and Food quality (2007-112; DWR). A new POD study will organize an expert panel to develop a suite of biomarkers that could be used as indicators of contaminant exposure or food quality.

*Synthesis for the Narrative Model*

The ultimate question for each of the stressors in the narrative model is the degree to which each has population-level effects. This question will be difficult to determine since population estimates are currently unknown. The gap will be addressed, in part, by one of the POD study elements to develop population estimates (see below); however, we acknowledge that the estimates may not be available until late in the study. To avoid delaying synthesis activities, synthetic study elements will emphasize modeling approaches that do not necessarily require absolute population estimates.

- Population modeling of delta smelt and striped bass (2007-041 and 2007-038; UCD, SFSU, LSU). These projects will include both age-structured matrix models and individual-based models that will help to evaluate the effects of each of the stressors on pelagic fishes. The striped bass effort will include a dose-response model to evaluate contaminant effects.
- Statistical analyses of pelagic fish abundance data (2007-084; USBR, consultants). Statistician Bryan Manly will continue his efforts to analyze the environmental factors that affect variation in pelagic fish abundance.
- Population estimates for pelagic fishes (2007-043; USFWS, USBR). Statistician Ken Newman will be working with IEP staff to determine whether existing trawl data could

be used for population estimates. As noted above, this issue is an important first-step in the evaluation of the population effects of different stressors.

- Analyses of historical abundance trends (2007-084; USBR). Consultant Bryan Manly's work with USGS staff on historical population dynamics will include statistical analyses of environmental factors affecting abundance trends.
- Comprehensive synthesis (2007-046; USFWS, USGS, DWR, DFG). Much of the synthesis effort for the POD program will be led by National Center for Environmental Analyses and Synthesis (NCEAS), who will organize a series of work teams of IEP and outside experts.



## Study Components

*Linkages among work plan elements:* All work plan elements relate to the narrative and matrix models. Identifying these linkages ensures that all stressors are pursued; linkages among stressors and studies are identified and should help in future syntheses of the POD results. The following table allows easy identification of the justification for each work plan element

Table 1. Relationships among POD work plan elements and narratives.

### 1. Expanded Monitoring

| PEN[1] # | Title | Narrative model connection | Matrix model link: Main stressors | Matrix model link: Minor stressors |
|---|---|---|---|---|
| 2007-003 | Fall Midwater Trawl | Both | 1-9 | |
| 2007-007 | Summer Townet Survey | Suisun | 1-9 | |
| 2007-072 | Environmental Monitoring program | Suisun | 1,2 | 6,7,8 |
| 2006-089 | Directed field collections | Both | 5-7,9 | |
| 2007-096 | Larval Fishes Survey | Suisun | 1,3,4,5,9 | |

### 2. On-going work

| PEN # | Title | | | |
|---|---|---|---|---|
| 2007-015, 2007-016, 2007-017 | South Delta fisheries and hydrodynamic studies | Salvage | 3,4 | |
| 2007-031 | Delta and Suisun Bay particle tracking investigations | Both | 3,4 | 1 |
| 2007-042 | Striped bass health investigations | Suisun | 5,6,9 | |
| 2007-045 | Phytoplankton primary production and biomass | Suisun | 1,8 | 3,6,7 |
| 2007-051 | Apparent growth rates of pelagic fishes | Suisun | 1 | 2,4-9 |
| 2007-060 | Evaluation of delta smelt otoliths | Both | 1 | 2,4-9 |
| 2007-061 | Pelagic fish liver histopathology | Both | 5,9 | 1,4,6-8 |
| 2007-062 | Fish diet and condition | Both | 1 | 2,4-9 |
| 2007-063 | Acute and chronic invertebrate and fish toxicity tests | Suisun | 5,6,7 | 2,9 |
| 2007-065 | Trends in benthic macrofauna abundance and biomass | Suisun | 8 | 1,2 |
| 2007-066 | Evaluation of changes in pelagic fish habitat quality | Both | 2 | 1,7,8 |
| 2007-068 | Analysis of recent changes in water operations | Both | 2,3,4 | 8 |
| 2007-078 | Retrospective analysis of long-term benthic data | Suisun | 8 | 1,2 |
| 2007-079 | Field survey of Microcystis bloom biomass and toxicity | Both | 7 | 2 |
| 2007-084 | Analysis of historical population dynamics | Both | 1-9 | |
| 2007-087 | Investigation of power plant impacts | Suisun | 4 | |

### 3. New work

| PEN # | Title | Conceptual model connection | Main stressors | Minor stressors |
|---|---|---|---|---|
| 2007-018 | Striped bass disease and contaminant loads | 2D | 5,9 | 1,6,7,8 |
| 2007-036 | Disease as a factor in the POD | 2D | 5,9 | 1,6,7,8 |
| 2007-038 | Development of striped bass and longfin smelt models | 5 | 1-9 | |

| | | | | |
|---|---|---|---|---|
| 2007-039 | Analysis of threadfin shad data - population dynamics | 1A | 1-5,7,9 | |
| 2007-041 | Modeling delta smelt populations in the S.F. Estuary | 5 | 1-9 | |
| 2007-043 | Estimation of pelagic fish population sizes | 1A | 1-9 | |
| 2007-044 | Zooplankton fecundity and population structure | 4A | 1,2,6 | 6,7,8 |
| 2007-046 | Overlap/Synthetic analyses of fish and zooplankton | 5 | 1-9 | |
| 2007-076 | Corbula salinity tolerance | 2C | 8 | 1,2 |
| 2007-081 | CASCadE | 2A | 2 | 3,4,8 |
| 2007-082 | Food web support for delta smelt and other estuarine fishes | 4B | 1,8 | 2,4,5,6,7 |
| 2007-086 | Gear Efficiency Studies | 1A | 1-9 | |
| 2007-097 | Hydrologic changes and Suisun Bay increased salinity | 2A, 3A | 3 | 2 |
| 2007-102 | SAV abundance and distribution | 2C | 2 | |
| 2007-107 | Fish facility history | 3A | 4 | |
| 2007-108 | Delta smelt culture facility | 2D, 3 | 3,4,5 | |
| 2007-112 | Biomarkers Workshop | 2D,4B | 5,6 | |
| 2007-115 | Striped bass bioenergetics | 3B | 1,2 | |
| 2007-116 | Striped bass adult population dynamics | 1A, 1B | 1,2 | |
| 2007-118 | Data mining for status and trends of predators | 3A | 1,2 | |
| 2007-119 | Delta fish biomass estimation | 1A | 1-9 | |
| 2007-120 | Relationship between habitat and distribution | 2B | 1,2 | 1,7,8 |
| 2007-121 | Endocrine disruptor study | 2D | 5,6 | 1,7,8 |
| 2007-122 | Food match-mismatch study | 4B | 1,2, 3 | 6, 8 |

[1] Program Element Number

| Stressor number and Stressor | |
|---|---|
| 1 | Food-fish mismatch |
| 2 | Habitat space |
| 3 | Adverse water movement |
| 4 | Entrainment |
| 5 | Toxic effects on fish |
| 6 | Toxic effects on fish food |
| 7 | Harmful algae |
| 8 | Corbula |
| 9 | Disease |

| Conceptual Model Components | |
|---|---|
| 1 | Prior and current fish abundance |
| 1A | Abundance trends |
| 1B | Trends in other population indicators |
| 2 | Habitat effects |



| | |
|---|---|
| 2A | Habitat changes |
| 2B | Habitat effects on pelagic fishes |
| 2C | Habitat changes for other organisms |
| 2D | Disease and contaminants |
| 3 | Top down effects |
| 3A | Water Diversions |
| 3B | Predation |
| 4 | Bottom up effects |
| 4A | Food availability |
| 4B | Food quality |
| 5 | Synthesis |

**Expanded Monitoring**

Expanded monitoring in 2006-2007 emphasizes gathering life-stage specific information on the target fish species, but effort will also include expanded collection of introduced jellyfish and a newly introduced shrimp, *Exopalaemon modestus* and updated distribution and abundance analyses. Jellyfish in the San Francisco Estuary are known to feed on copepods and rarely larval fish, and anecdotal evidence suggests that introduced species have recently increased in abundance in the upper estuary (Rees and Kitting 2002). The distribution and seasonal abundance of jellyfish has been investigated (Rees and Kitting 2002, Moreno 2003), but until recently data for trend analyses has been absent. Starting in the early 2000s the San Francisco Bay Study and the Fall Midwater Trawl Survey began identifying and counting jellyfish (Honey et al. in prep). These data will be summarized and additional collections started (see Summer Townet Survey below) to investigate whether jellyfish might be a factor in the pelagic fish decline. The freshwater shrimp, *Exopalaemon modestus*, has dramatically increased in abundance since it was first documented in the estuary in 2000 (Brown and Hieb in prep). Based on the diet of a similar species (Sitts 1978, Siegfried 1982), this shrimp could affect abundance of mysids, amphipods and copepods within its range. We plan to update and expand abundance and distribution information summarized in Brown and Hieb (in prep). Additional revisions are summarized by elements below.

**I. Expanded Monitoring**
***Fall Midwater Trawl (FMWT)***
IEP 2007-003
Point person: Randy Baxter (DFG)
Lead Agency: DFG
Questions: What is the relative abundance (via abundance index) of striped bass, delta smelt and other pelagic fishes of the upper estuary? Can these data be used to estimate apparent mortality?
Description: This survey targets age-0 striped bass and other pelagic species 30-150 mm in length using a midwater trawl towed through the water column for 12 minutes in a stepped oblique manner (Stevens and Miller 1983). There are 116 stations located from San Pablo Bay upstream through Suisun Marsh and Bay and into the Delta. In September 2005 a zooplankton tow at 32 selected sites was conducted, and for a subset of 10 sites, water was collected for invertebrate toxicity tests (Werner, 2005 3e). Delta smelt and striped bass heads and bodies were

preserved separately for otolith and histopathological analyses, respectively (Bennett 2005 3a and Teh 2005 3b) or fish were preserved intact for diet and condition analyses (Gartz and Slater 2005 3c). In 2006, sampling continued as described above, except that water collections for toxicity testing (2007-063) will employ a separate boat and crew, longfin smelt, threadfin shad, and inland silversides will be collected for diet and condition, zooplankton sampling will take place only in September and October.

Time period: Sampling is conducted monthly from September through December and takes 2 weeks to complete.

Resources required

Cost: The IEP FMWT budget is $328,000. An additional $3,000 required to do this work was already obtained in 2006 from POD sources.

PI(s): Randy Baxter (DFG) and Dave Contreras (DFG)

Contract needed / in place: N/A

Contract manager: N/A

Term of contract: N/A

Personnel: The field component of this project requires 1 boat operator, 1 biologist, and 1 scientific aide. The laboratory component requires numerous personnel for preseason preparation, fish identification, data validation, diet and condition procedures, and stomach content analysis.

Equipment: A boat with davits and hydraulics appropriate to pull a midwater trawl net, (such as the *R/V Scrutiny)*, laboratory facilities, warehouse space, formalin, ethanol, and suitable containers for sample collection and preservation.

Deliverables and dates: Survey by survey indices will be calculated and checked by the end of each month and annual indices for POD fishes will be complete by the first of the new year. An article is completed each spring for the Status and Trends edition of the IEP Newsletter. Also trends in distribution and abundance of jellyfish will be examined for data collected since 2001. Zooplankton identification and CPUE calculation will be completed at the end of the year, and will contribute to the fish and food-item match –mismatch analysis (2007-122).

Comments: The FMWT Survey collected delta smelt and striped bass for otolith and histopathology investigation, but did not collected sufficient numbers of either to support all the projects in 2005, so additional field collections were necessary. A similar circumstance is expected for 2006 and 2007. This survey currently reports annual abundance indices for 6 fishes and has collected count data on jellyfish since 2001. The ratio of same-year FMWT to TNS indices for age-0 striped bass is used as an index of summer survival (Stevens et al. 1985). This survey is mandated in the 2004 OCAP Biological Opinion for delta smelt.

***Summer Townet Survey***

IEP 2007-007

Point person: Randy Baxter (DFG)

Lead Agency: DFG

Questions: What is the relative abundance (via abundance index) of striped bass and delta smelt? Can these data be used to estimate apparent mortality? How are juvenile striped bass and delta smelt distributed in relation to potential food items? Is the density of food items related to fish condition, growth rate or health indices?

Description: The Summer Townet Survey (TNS) has collected juvenile fishes in the range of 20 to 50mm since 1959 (Turner and Chadwick 1972). Samples are collected using a conical net



with a 1.5 $m^2$ mouth and 12.7-mm (½ in) stretched mesh nylon lashed to a hoop frame and mounted on skis. Three, 10-minute oblique tows are made against the current at each of 32 stations located from eastern San Pablo Bay to Rio Vista on the Sacramento River and Stockton on the San Joaquin River. This survey was expanded in 2005 to include simultaneous zooplankton sample from each station, water collections for invertebrate toxicity tests (Werner, 2005 3e) at a subset of 10 stations, and a water quality profile at every station. The water quality measurement was be conducted with a YSI 6600 Sonde that collects temperature, depth, dissolved oxygen, turbidity, chlorophyll *a*, conductivity, salinity, pH, date, and time. Also, delta smelt and striped bass heads and bodies were preserved separately for otolith and histopathological analyses, respectively (Bennett 2005 3a and Teh 2005 3b) or were preserved for diet and condition analyses (Gartz and Slater 2005 3c). In 2006, sampling continued as described above, except that: water collections employed a separate boat and crew; due to time and equipment limitations, only bottom and surface water quality measures were taken; longfin smelt, inland silverside and threadfin shad were collected along with delta smelt and striped bass for diet and condition; and numeric and volumetric estimation of jellyfish abundance did not begin.

Time period: Every other week from June through August.

Resources required

Cost: The IEP TNS budget is $273,000. The POD TNS budget is $23,000. An additional $60,000 required to complete this work was already obtained in 2006.

PI(s): Randy Baxter and Jason Dubois (DFG)

Contract needed / in place: N/A

Contract manager: N/A

Term of contract: N/A

Personnel: The field component of this project requires 1 boat operator, 1 biologist, and 1 scientific aide. The laboratory component requires numerous personnel for preseason preparation, larval fish identification, zooplankton identification, data validation, length weight procedures, and stomach content analysis.

Equipment: A boat with an A-frame and hydraulics appropriate to pull a sled-mounted townet (such as the *R/V Scrutiny or Munson)*, laboratory facilities, warehouse space, formalin, ethanol, and suitable containers for sample collection and preservation.

Deliverables and dates: Survey indices for striped bass (38-mm Index) and delta smelt will be produced by September 1 of each sampling year and reported to all Agencies through the POD Management Team. These indices will be part of any conference abundance-trend updates for CALFED Science or IEP, and will be published the following spring in the Status and Trends edition of the IEP Newsletter. Also trends in distribution and abundance of jellyfish will be examined for data collected since 2001. Zooplankton identification and CPUE calculations will be completed at the end of the year and will contribute to the fish and food-item match – mismatch analysis (2007-122).

Comments: The TNS collected delta smelt and striped bass for otolith and histopathology investigations, but did not collect sufficient numbers of either to completely support those projects in 2005, so additional field collections were necessary and were added in 2006. A similar circumstance is expected for 2007. TNS catch data are used to calculate the striped bass 38.1 mm index (Turner and Chadwick 1972) and an annual abundance index for juvenile delta smelt (Moyle et al., 1992). This survey is part of the long-term monitoring carried out by IEP and is mandated in the 2004 OCAP Biological Opinion for delta smelt.

***Environmental Monitoring Program***
IEP 2007-072
Point person: Randall Baxter (DFG)
Lead Agency: DWR and DFG
Questions: How well is abundance (density) of microzooplankton estimated by the historical and alternative methods for common and uncommon taxa? What can be inferred about the effectiveness of historical methods and data from these results? Can microzooplankton data be used to estimate mortality rates and construct a vertical life table? What changes in protocol are recommended for the future long-term monitoring?
Description: As part of the environmental monitoring program (EMP), water quality, chlorophyll a, benthos and three types of zooplankton samples are taken monthly at up to 21 locations distributed from eastern San Pablo Bay upstream into the Sacramento and San Joaquin rivers. Since 1972, microzooplankton samples have been collected by lowering a 15 L/min pump from the surface to the bottom and back to the surface two times, capturing the discharged water in a large carboy and taking a 1.9 L subsample of this mixture preserved with formalin to examine completely for zooplankton. The accuracy and precision of resulting density estimates has been questioned, so a study commenced in fall 2005 to compare traditional methods and gear including: 1) examination of a larger sample volume collected with the same pump and 2) examination of a much larger sample volume collected using a higher capacity pump. In the latter 2 cases, sub-sampling methods will be used, which were not necessary with the low volume of traditional sampling. The 3-types of pump samples will be collected and examined from each sampling location monthly through at least June 2006. Initially, only a fall and spring subset of samples will be examined to identify the optimal gear and method and additional samples archived. If analyses indicate increased volume or the new pump substantially improves accuracy and precision, then the program will adopt the new method or pump and 2006 samples collected in the selected manner will be completely examined.
Time period: Sampling has been concluded in 2006. Sample and data analysis will continue in 2007.
Resources required
Cost: The POD EMP budget is $122,000. The IEP EMP budget is $3,034,000.
PI(s): Dean Messer, Anke Mueller-Solger (DWR)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: A single supervising laboratory assistant identifies organisms from all samples. EMP staff at DWR is responsible for data analysis.
Equipment: Lab equipment available at the DFG lab in Stockton.
Deliverables and dates:
Comments: Recommendations for changes in sampling derived from this investigation will likely be incorporated into Program protocol. This program is mandated by Water Rights Decision 1641.

***Directed field collections***
IEP 2007-089
Point person: Randy Baxter (DFG)



Lead Agency: DFG and DWR
Questions: There are no questions related to the Directed Fish Collections effort. Questions are listed under the project description that the fish are being collected for (2007-040, 2007-042, 2007-060, 2007-061, 2007-062, and 2007-063).
Description: Directed, short-term field collections. In 2005 and 2006 directed collections were used to increase the number of delta smelt and striped bass available for otolith analyses and histopathology, and to collect inland silversides for diet and condition. Directed collections were also used to collect water for fish toxicity tests. In 2007, directed collections will be used to collect water for both invertebrate and fish toxicity tests (see 2007-063) and they may be used for some gear efficiency tests, if time permits. Regular once or twice monthly sampling efforts were made to enhance POD fish collection and to allow time for field examination of larval and young juvenile fishes. As staff and boat time permits, directed sampling will continue to be used to enhance collection of target fishes.
Time period: As needed and when staff and boats are available. For water collections, sampling will take two weeks per month.
Resources required
Cost: The 2007 IEP budget for Directed Field Collections is $75,000 from POD sources. $143,000 required for this work was already obtained in 2006.
PI(s): Inge Werner (UCD), Swee The (UCD), Bill Bennett (UCD), David Ostrach (UCD), Steven Slater and Randy Baxter (DFG).
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Water sampling - one boat operator and one crew member from participating research group; Fish sampling - one boat operator, one scientific aid or biologist and 1-3 researchers from participating research group. In addition, the point person contributes substantial time coordinating logistics for PIs and field crews.
Equipment: Water sampling – 20-32 ft. vessel with sufficient deck space for 8-10 large coolers. Fish sampling – 25-42 ft. vessel capable of deploying trawl gear targeting late stage larvae through juveniles; vessel and gear will change as life stage of fishes progress.
Deliverables and dates: See specific project descriptions listed above for this information.
Comments:

***Larval Fish Survey***
IEP 2007-096
Point person: Randy Baxter
Lead Agency: DFG
Questions: In 2006, we addressed the question – "Can the distribution of larval delta smelt be effectively determined using surface-oriented plankton nets when compared to catches from traditional ichthyoplankton gear and methods?" – and found the answer to be no. For 2007
Description: Using 2005-2006 sampling data, this survey compared catches of delta smelt larvae and those of other species between surface-towed nets and nets retrieved in the traditional oblique manner (IEP 1987; Rockriver 2004, Dege and Brown 2004) to determine if surface catch is sufficient to effectively document species distribution. Two field seasons of data collection (2005-2006) were planned as the basis for evaluating the surface oriented nets. If surface-oriented larva tows prove sufficient (they may not, see Rockriver 2004), then concurrent larva

and 20mm Survey sampling could take place to simultaneously target larva and post-larva to small juveniles. The alternatives of conducting two oblique tows in succession or two separate surveys for larva and 20mm fish are not feasible with current staff and boats. In 2006, sampling will begin in January to facilitate capture of larval longfin smelt, will include collection of zooplankton samples and will cover the 41 20-mm Survey stations plus 3 additional locations in the main channel of central and eastern San Pablo Bay.
Time period: Every other week from January through early July.
Resources required
Cost: The POD DSLS budget is $97,000. The IEP DSLS budget is $177,000. An additional $80,000 required to do this work was already obtained in 2006.
PI(s): Kevin Fleming (DFG) and Julio Adib-Samii (DFG)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: The field component of this project requires 1 boat operator and 2 scientific aides. Numerous lab personnel are associated with preseason preparation, lab processing of samples, zooplankton and larval fish identification.
Equipment: This project requires the use of the *RV Munson* since it is the only boat equipped with fore-mounted larval nets. It also requires wet lab space to process approximately 400 quart jar samples that are collected throughout the field season.
Deliverables and dates: Completion of data analysis is planned for fall 2006.
Comments: The 2005 and 2006 surveys replaced the North Bay Aqueduct monitoring on a pilot basis as required by the USFWS 2005 OCAP Biological Opinion for delta smelt. The Delta Smelt Workgroup designed this survey as a two year trial. Protocol and methods developed in 2005 were used in 2006. Surface tows proved ineffective for larval delta smelt (Mayfield in prep.) so the USFWS asked the Delta Smelt Workgroup to modify the sampling design for 2007. The timing and locations of delta smelt larva sampling in 2007 will be guided by catches of ripe and spent adult delta smelt caught in the Spring Kodiak Trawl Survey (Kevin Fleming, DFG, pers. comm.).

## II. On-going Studies

***Larval fish behavior study***
IEP 2007-017
Point person: Ted Sommer
Lead Agency: USBR, USGS and DWR
Questions: What are the behaviors of larval fishes in the south Delta and how is behavior likely to affect entrainment risk under different hydrologic conditions?
Description: This is part of the separately-funded South Delta Hydrodynamics and Fisheries investigation that was initiated in 2004. Its goal is to develop a behavioral model of larval fish behavior to support estimation of entrainment risk in the south Delta under differing hydrologic and operations scenarios.
Time period: The second phase of field data collection was completed during spring 2005; a summary report should be available shortly. Further work will be ongoing through 2007.
Resources required



Cost: This element is funded by non-POD sources.
PI(s): Lenny Grimaldo (DWR)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel:
Equipment:
Deliverables and dates: The second phase of field data collection was completed during spring 2005; a summary report should be available shortly. Further work will be ongoing through 2007.
Comments:

***Delta and Suisun Bay hydrodynamics investigations relying on particle tracking models***
IEP 2007-031
Point person: Ted Sommer (DWR)
Lead Agency: DWR and USBR
Questions: How does the spatial distribution of entrainment risk vary under different hydrologic (flows and exports) and operations (DCC, south delta barriers) scenarios? How does risk of (power plant) entrainment in Suisun Bay and environs vary with environmental conditions and power plant operations? How does risk of exposure to adverse physical or chemical conditions created by power plant operations vary with environmental conditions and power plant operations? What geographical areas do samples taken at IEP trawl stations actually represent?
Description: This is a three-pronged element. The first prong shares the goals of the South Delta Hydrodynamics and Fisheries studies: to understand the transport of fishes through the delta and to determine whether adjustments to water project operations may allow a useful reduction in entrainment of protected fish species. For the foreseeable future this work will be conducted using DSM2 and the DSM2 particle tracking model. While this part of the element is fish-oriented, we plan to adapt the investigation if possible to couple model outputs with distribution data and production models for lower trophic level organisms to assess the likelihood that water diversions could significantly influence regional productivity under certain circumstances. The second prong of the element is an investigation that will consist of particle tracking studies of Suisun Bay and surrounding waters to support the power plant operations element of the work plan. The intent will be to estimate entrainment risk and risk of exposure to high temperatures and/or chlorine produced by the Pittsburg and Contra Costa power plants. Initial work will rely on DSM2 and its PTM, but we plan to replace it with more sophisticated 3-D tools during the study period. The third prong is PTM support for development of population size estimation in the IEP field surveys. We plan to use reverse-PTM to help estimate the boundaries of sampling regions represented by fixed stations in the surveys. This work will rely on DSM2 and its PTM.
Time period: Follow-up 2005 PTM studies underway. Other applications will be ongoing through 2007.
Resources required
Cost: $49,000 from POD sources. Use of 3-D technologies will require contracting with an outside entity and the cost of this is unknown at present.
PI(s): The key staff includes Mike Mierzwa, Ted Sommer and Bob Suits (DWR) and Mike Chotkowski (USBR).
Contract needed / in place: N/A
Contract manager: N/A

Term of contract: N/A
Personnel:
Equipment:
Deliverables and dates:
Comments: Additional study questions will be developed by the POD Flows and Operations PWT.

***Striped bass health investigations***
IEP 2007-042
Point person: Marty Gingras (DFG)
Lead Agency: UCD, support from DFG
Questions: Does the condition of adult or larval striped bass suggest that contaminants and diseases could be depressing the populations of striped bass in the estuary? If present, have these effects increased in recent years? What life stages are most critical?
Description: This work will assess the health status of larval, juvenile, and adult female striped bass collected from selected locations in the Bay Delta using morphometric, histopathological, otolith (aging, growth and microgeochemical analyses) and biochemical metrics. Comparison with archived samples will allow for estimation of the contribution of this type of stressors to the long vs. short-term declines in abundance of young striped bass.
Time period: Analysis of archived samples can begin as soon as contracts are in place. Gravid females will start arriving on the spawning grounds in April and May, and be sampled by DFG as part of their normal operations.
Resources required
Cost: $416,000 from POD sources.
PI(s): David Ostrach (UCD)
Contract needed / in place: In place.
Contract manager: Ted Sommer (DWR)
Term of contract: Through September 14, 2007.
Personnel:
Equipment:
Deliverables and dates: Reports on results of the adults and larvae are due by March 30, 2007 and September 14, 2007.
Comments: The investigator has a great deal of experience and unpublished information on this topic. Transforming new and accumulated data and information into peer-reviewed literature must be an essential part of this element. The additional laboratory and modeling work proposed by the investigator would cost another $240 but may not be available separately in 2007.
The additional proposed work not funded in 2006 is more experimental and may not be as conclusive as the work proposed for funding.

***Phytoplankton primary production and biomass in the Delta***
IEP 2007-045
Point person: Anke Mueller-Solger
Lead Agency: UCD, DWR-DES
Questions: What are long-term patterns and trends in phytoplankton production and biomass and other water quality variables in different Delta subregions and at specific locations? How do they compare to Delta-wide trends? What factors may be responsible for these patterns and trends?



How may the Delta food web be affected by these patterns and trends? Have changes in water exports affected phytoplankton in different Delta areas? Do the previous questions differ when only "nutritious" algae are considered? Can monitoring data be used to evaluate benthic grazing rates?
Description: This is an extension of an ongoing data analysis project with CALFED-ERP funding granted to Dr. Alan Jassby at UC Davis and collaborators at DWR-DES. The full title is "Primary Production in the Delta: Monitoring Design, Data Analysis and Forecasting." Phytoplankton production is at the base of the pelagic food web leading to the zooplankton and fish species currently experiencing rapid declines. One goal of this ongoing project is to analyze available historical data on chlorophyll *a* concentrations and other water quality variables in Delta sub regions or at specific long-term monitoring stations in order to determine processes underlying changes in primary production and biomass. This is an extension of similar analyses conducted at the Delta-wide scale (Jassby and Cloern 2000; Jassby et al. 2002). Results from this study will help assess the potential for sub-regional and local bottom-up food web effects on pelagic zooplankton and fish, effects of changed export patterns on phytoplankton production in different Delta areas, etc.
Time period: Ongoing through 2007.
Resources required
Cost: $50,000 per year from POD sources.
PI(s): Dr. Alan Jassby (UCD), in collaboration with DWR-DES staff (Anke Mueller-Solger & Marc Vayssières)
Contract needed / in place: In place
Contract manager: Ted Sommer (DWR)
Term of contract: Through June 30, 2008.
Personnel:
Equipment:
Deliverables and dates: An IEP newsletter article, progress report, and a presentation (CALFED or IEP) are due by June 30, 2007. By June 30, 2008, the deliverables will be an IEP newsletter article, a final report (an IEP technical report is intended), and at least one peer-reviewed journal article.
Comments:

***Apparent growth rates of pelagic fishes and relationship to abundance***
IEP 2007-051
Point person: Randy Baxter (DFG)
Lead Agency: DFG
Questions: Have species' apparent growth rates or year-end mean lengths declined, particularly those of 2001-2004 versus previous years? Are environmental factors, such as X2 position or zooplankton abundance, predictive of apparent growth rates or year-end mean size?
Description: Complete growth rate analyses based on existing length frequency data from the trawl surveys to determine if the apparent growth rates of target pelagic fishes have changed over the long-term and/or recently (2002-2004).
Time period: We are examining various data sets for these analyses and propose to complete analyses by March 2007.
Resources required

Cost: The 2007 POD budget for this element is $38,000 from POD sources. $39,000 required to complete this work was already obtained in 2006.
PI(s): Randy Baxter, Kathy Hieb, Kevin Fleming, (DFG)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Existing IEP staff and funds can be redirected to this analysis.
Equipment: There are no field or laboratory requirements for this project.
Deliverables and dates: Two progress reports; March and August 2007.
Comments:

***Evaluate delta smelt otolith microstructure and microchemistry***
IEP 2007-060 and 2007-040
Point person: Randy Baxter (DFG)
Lead Agency: UCD
Questions: Do growth rates of delta smelt vary seasonally or geographically? When and where in the estuary are delta smelt produced?
Description: Analysis of otoliths from delta smelt to determine daily growth rate and area of origin. Analysis of otoliths that includes microchemical work can provide detailed information on fish origin and growth that can be related to histopathology analyses and potentially to ambient water toxicity for 2005 and 2006. This work has been done successfully on delta smelt (Bennett submitted). Fish samples for this element will be collected by TNS and FMWT surveys, with supplemental sampling based on availability of boats and crew. In addition IEP has archived delta smelt samples from 1995 through 2005 that might be added to these analyses.
Time period: Work should be started as soon as practical and continue for at least one year.
Resources required
Cost: Estimate is $350,000 to process approximately 500-600 samples per year. Funding to come from a CALFED ERP grant. $76,000 funding for J. Hobbs is from CALFED – Sea Grant.
PI(s): Dr. Bill Bennett (UCD) and James Hobbs (UCD)
Contract needed / in place: In place
Contract manager: Steven Rodriguez (DFG)
Term of contract:
Personnel: Field personnel are supplied by DFG Townet, Fall Midwater Trawl and 20-mm surveys, and targeted sampling.
Equipment:
Deliverables and dates:
Comments: This work will be an extension of the delta smelt work (Bennett submitted) and striped bass work carried out by Dr. Bill Bennett and colleagues (Bennett et al. 1995). This work would be most effective if coupled with the histopathology work (2007-061) and diet/condition work (2007-062) to provide a comprehensive timeline of the relative condition of the fish that we could compare to timing of potential stressors.

***Delta smelt histopathology investigations***
IEP 2007-061
Point person: Randy Baxter (DFG)
Lead Agency: UCD



Questions: Does fish histopathology suggest recent increases in toxic exposures and/or food limitation? Does the histopathological condition vary in severity by life stage within or among species and/or geographic regions? What percentage of fish is affected by environmental stressors? What are the target organs of these stressors, and can the observed effects lead to population declines? What are the stressors affecting the fish?
Description: Histopathological examination of fish. Work in 2006-07 will focus on the examination of fish exposed to water samples or collected from sites where 1) 2005 results indicated that fish were affected by environmental stressors; 2) where invertebrate toxicity indicate the presence of toxic compounds. Lesions in fish from important studies should be compared to lesions observed in fish from filed sites, but it is important to keep in mind that actual exposure duration may differ between laboratory-exposed and field-collected fish, and that wild fish may additionally be exposed to natural stressors (water temperature, oxygen levels, and food depletion.)
Time period: 2006-2007.
Resources required
Cost: $350,000 from CALFED ERP grant
PI(s): Dr. Swee Teh (UCD)
Contract needed / in place: In place
Contract manager: Steven Rodriquez (DFG)
Term of contract:
Personnel: Field personnel are supplied by DFG Townet, Fall Midwater Trawl and 20-mm surveys, and targeted sampling.
Equipment: Field sampling vessels and nets, as well as laboratory supplies needed for storage and preservation of specimens are supplied by DFG. Laboratory analysis is conducted at UCD.
Deliverables and dates:
Comments: Histopathological analysis of fish tissues can identify a variety of tissue lesions resulting from exposure to environmental stressors such as contaminants, disease, and food limitation. Histopathological lesions often manifest themselves over longer periods of time, and therefore integrate the effects of multiple stressors. It is a useful tool to identify affected organs and can help identify certain groups of contaminants with known mechanism of action (e.g. carcinogens, endocrine disruptors) and target organs (e.g. liver, gonads). Histopathological studies play an important role in directing and focusing special studies.

***Quantitative analysis of stomach contents and body weight for pelagic fishes***
IEP 2007-062
Point person: Randy Baxter (DFG)
Lead Agency: DFG
Questions: Is there evidence of reduced feeding success during specific times of the year or in certain parts of the estuary? If so, are these changes associated with changes in growth rate, relative weight or liver condition? Do stomach content, condition (weight at length) or histopathology vary between salvaged fish and fish collected elsewhere?
Description: Food habit studies have been done on many of the fish and zooplankton found in the estuary (IEP 1987; Orsi 1995; Lott 1998; Nobriga 2002; Feyrer et al. 2003); however, many of these studies were done more than 10 years ago and the feeding habits of the local inland silverside and threadfin shad populations have only been studied in a limited geographical range

(Grimaldo 2004). As evidence that feeding success may be an important issue for survival, initial studies by BJ Miller suggest that delta smelt survival in different parts of the estuary was linked to whether there was co-occurrence of prey. The only previous evaluation of parasite load was an evaluation of cestode infection in striped bass (Arnold and Yue 1997). However, information on gut parasites can be collected quickly during the processing for stomach contents analysis. Parasite load can influence susceptibility to other stressors (Moles 1980). In 2003, IEP started a study of fish length-weight relationships needed to estimate species biomass and to develop a program to monitor trends in relative weight. Work on diet and condition will be continued in 2006 and 2007, and be expanded to include longfin smelt among the target species and the periodic collection of all target fishes (delta smelt, striped bass, longfin smelt and threadfin shad) from Salvage. In 2006, examination of parasite load was transferred to researchers conducting histopathological investigations (2006-061, 2006-042).

Time period: 2006 and 2007

Resources required

Cost: The 2007 POD budget is $11,000. $66,000 required to do this work was already obtained from POD sources in 2006.

PI(s): Randy Baxter and Steve Slater (DFG)

Contract needed / in place: N/A

Contract manager: N/A

Term of contract: N/A

Personnel: Field collection is conducted by all long-term fish monitoring surveys. Fish are retained after reaching quotas for otolith and histopathology samples; all POD fishes are retained by Bay Study for condition and diet analyses. Laboratory personnel (3 scientific aids and part time Sr. Lab Assistant) are directed in sample processing by a Biologist.

Equipment: Current long-term monitoring vessels and gear will be employed; some gear modification may occur for directed sampling. Laboratory equipment is currently available at DFG Stockton.

Deliverables and dates: Posters for CALFED Science Conference, October 2006. Oral progress report, December 2006. Poster and oral presentation for IEP Asilomar Workshop, February 2007. Fish length-weight and diet databases will be added to until the start of 20mm Survey redirects lab staff in March of each year. Additional specimens will be archived for future investigation or increased sample size when staff time permits.

Comments: DFG staff will collect samples and process diet information. The IEP has extensive experience with these techniques, but lost staff leading part of this work. Lab work was delayed substantially in 2006 by the loss of a biologist and long delays in hiring Scientific Aides and Senior Lab Assistants.

***Acute and Chronic Invertebrate and Fish Toxicity Tests***

IEP 2007-063

Point person: Randy Baxter (DFG)

Lead Agency: UCD

Questions: Is water in the Delta and the Napa River toxic to pelagic fish and fish food organisms? If yes, where and when? How does fish and zooplankton distribution and abundance compare to bioassay results? What is the spatial and temporal distribution of water column toxicity in relevant areas of the Delta? What are the primary toxicants?



Description: Work in 2006-07 will consist of a spatially and temporally expanded sampling and toxicity testing program. Spatial distribution of Delta sampling sites will follow the 2005 pilot program, and additional sites will be sampled in accordance with the prevalent distribution patterns of fish species of concern. The indigenous amphipod species, *Hyalella azteca*, will be used for routine toxicity testing throughout the year. This species is resident in the Delta, sensitive to contaminants, and is routinely used in toxicity testing programs throughout the Nation. Moreover, it can be used to identify the causative agents of toxicity through Toxicity Identification Evaluation (TIE) procedures. If toxicity is observed at a site through initial screening, TIEs will be initiated immediately. Adequate quantities of water will be collected to proceed with TIEs in case toxicity is observed.

Two fish species of concern (delta smelt and striped bass) will be used to test water samples from selected Delta sites, from larval to juvenile stages during periods when the respective life stages are rearing in the Delta. Fish from these tests will be preserved for biomarker and histopathological analyses. These laboratory tests will identify sites that are acutely toxic to larval/juvenile stages of delta smelt and striped bass, and help differentiate the effects of toxic contaminants from the effects of food depletion (fish will be fed during the laboratory trials), and natural stressors such as water temperature and/or oxygen depletion (laboratory tests are performed at constant temperature and water is oxygenated).

If multiple stressor effects are suspected to play a role (e.g. food limitation plus contaminants), laboratory experiments could help quantify the combined effects. Fish could be reared in the laboratory under a normal and a food-limited regime, examined for resulting histopathological lesions, then exposed to water from different Delta sites, or to specific contaminants identified as toxicants present in the Delta.

Time period: 2006-2007

Resources required

Cost: $644,000 from POD sources.

PI(s): Inge Werner (UCD)

Contract needed / in place: Yes

Contract manager: Ted Sommer (DWR)

Term of contract: Through December 2007.

Personnel: Field water collection will be facilitated by a DFG boat operator; otherwise, UC Davis personnel will conduct all preparation and processing.

Equipment: Field collection via a 20-32 foot research vessel supplied by DFG. Bioassay and TIE equipment currently available at UC Davis Aquatic Toxicology Lab.

Deliverables and dates: Quarterly progress reports to Contract Manager; oral progress reports to IEP project work teams by September 2006 and September 2007; oral progress report at the IEP Annual Workshop in February 2006; peer-reviewed professional journal article and/or report in the summer 2007 IEP Newsletter.

Comments: In addition, information will be gathered on land use (e.g. PUR) to ascertain the potential class of toxicant(s) that could potentially be present at the sampling sites (see contaminant trends). This will aid in the TIE process, and also direct focused studies on timing and duration of potential toxic effects.

If TIE work identifies specific contaminants as toxicants of concern, focused laboratory studies should be designed and performed to expand our knowledge of the specific effects and biological effect levels of these toxicants. Specific biomarker responses can then be selected for identifying the effects of these toxicants in field studies

***Trends in benthic macrofauna biomass***
IEP 2007-065
Point person: Anke Mueller-Solger (DWR)
Lead Agency: DWR
Questions: At central & northern Delta locations, what are the long-term trends in biomass, production, and grazing rates of benthic species? How are these changes related to physical-chemical gradients? How do changes in benthic functions such as production and grazing affect the pelagic food web?
Description: Over the past three decades, the Interagency Ecological Program (IEP) Environmental Monitoring Program (EMP) has collected benthos community composition and abundance information at 22 sites, including four long-term monitoring stations. Trends at the four long-term stations are the subject of an ongoing investigation. Though it is presently recognized that biomass data are crucial in determining the role of benthic organisms in the ecosystem, (especially the feeding potential of various functional groups, potential availability and transmission of contaminants bioaccumulated in benthos, and trends in production as well as the ecological significance of changes in benthic community composition and abundance) measurements of benthic macrofauna biomass have never been conducted by the EMP. Fortunately, the EMP has developed a comprehensive plan to analyze archived benthos samples dating back to 1975 which can be used for biomass estimation using a simple wet-weight method. The objective for 2006 was to measure and examine the biomass of benthic organisms collected quarterly from 1975 – 2004 at two long-term stations located in the central and northern Delta. Data analysis is conducted as part of work plan element IEP 2007-078 and other ongoing EMP data analyses. This work will continue in 2007.
Time period: 2006-2007
Resources required
Cost: Redirected staff from the EMP (2007-072) will be used to accomplish this work. Additional funding for an expansion of this project has recently been granted by the CALFED Science Program. This funding will likely become available by the end of 2007 or early in 2008.
PI(s): Dean Messer (DWR), Karen Gehrts (DWR), Wayne Fields of Hydrobiology would provide identification help and Dr. Janet Thompson, USGS, would provide additional expertise.
Contract needed / in place:
Contract manager:
Term of contract:
Personnel: Scientists: 365 hours = $31,400; 1 Scientific Aide: 550 hours = $21,110; Wayne Fields: 30 hours = $3000.
Equipment: Supplies: $10,000
Deliverables and dates:
Comments: Investigation does not depend on the availability of new field data. Special analytical techniques that are required are well-known.

***Evaluation of changes in pelagic fish habitat quality using the IEP long-term monitoring data***
IEP 2007-066
Point person: Ted Sommer (DWR)
Lead Agency: DWR and DFG



Questions: Has the surface area of suitable striped bass and/or delta smelt habitat changed? Does interannual variation in estuarine hydrology influence the spatial extent of striped bass and/or delta smelt habitat? Have export changes affected the spatial extent of striped bass and/or delta smelt habitat? What are the trends in physical habitat area in the Delta versus Suisun Bay? Do the previous findings differ when the availability of zooplankton prey are factored into the analysis?
Description: Long-term monitoring data are being used to characterize physical habitat for delta smelt and striped bass and to test the hypothesis that there has been no long-term change in the amount of physical "habitat" for these pelagic fishes. The basic approach used in 2005 was similar to instream flow methods (IFIM) that have been applied to rivers and streams. First, we developed habitat criteria to define the physical and chemical conditions that were suitable for striped bass and delta smelt. Second, we divided the study region into smaller area units based on the location of sampling (TNS and MWT) stations. Third, we applied the habitat criteria (step 1) to long-term water quality monitoring data for each station to determine which stations provided suitable habitat. Finally, we summed the area units (step 2) representing suitable habitat to provide an estimate of total suitable area. Note that a major difference between our approach and traditional IFIM methods is that we relied on actual water quality monitoring data at sampling stations to calculate suitable habitat, while IFIM typically uses model simulations to generate data for each station. In 2006-2007 we propose to: 1) Complete the initial analyses of habitat area for the TNS and MWT; 2) submit results to a peer-reviewed journal for publication; 3) evaluate the results based on trends in physical habitat for major geographical areas (e.g. delta vs. Suisun Bay); and 4) evaluate the feasibility of using zooplankton prey availability as an additional habitat suitability criterion.
Time period: 2006-2007
Resources required
Cost: $184,000 from POD sources
PI(s): Matt Nobriga, Fred Feyrer, and Ted Sommer (DWR)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Two Environmental Scientists at 25% time. Additional assistance of redirected IEP staff may also be needed.
Equipment: There is no field or lab component to this study.
Deliverables and dates: Two peer-reviewed journal articles will be prepared by June 30, 2007.
Comments: This study component is a continuation of the successful 2005 effort.

***Recent changes in water project operations***
IEP 2007-068
Point person: Rich Breuer (DWR)
Lead Agency: DWR
Questions: This element will address two major questions: 1) how have water project operations changes in recent years; and 2) what is the cause of fall salinity increases in the delta?
Description: This project will use hydrologic data from the delta and upstream areas to identify changes that have occurred in water project operation during the pelagic fish decline.
Time period:
Resources required

Cost: There are no additional funds required to accomplish this work.
PI(s): Lenny Grimaldo (DWR)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Existing staff members will be redirected to accomplish this task.
Equipment:
Deliverables and dates:
Comments:

***Retrospective analysis of long-term benthic community data***
IEP 2007-078
Point person: Anke Mueller-Solger (DWR)
Lead Agency: DWR & USGS
Questions: At the 4 core sites, how do benthic community assembly and structure change over time? How are these changes related to physical-chemical gradients? Can spatial or physical thresholds be identified for benthic macrofauna, especially for species of concern such as invasive species, species with important trophic effects, (e.g. *Corbicula fluminea* and *Corbula amurensis* which act as a sink for suspended organic particles), and other benthic species that are important prey items for higher trophic levels such as bird, fish and mammals? What is the environmental significance of changes in species assemblage?
Description: This is an ongoing data analysis project with IEP and CALFED-Science funding. The goal of this project is to investigate long-term trends and ecological processes involving benthic organisms from historical data collected by the IEP Environmental Monitoring Program (EMP) at its four long-term benthos monitoring stations. Specifically, this analysis seeks to uncover historical trends in community composition in relation to environmental variability, hydrology, and exotic species invasions.
Time period: ongoing through 2007
Resources required
Cost: Existing staff will be redirected to accomplish this task.
PI(s): Key staff includes Heather Peterson (USGS), Marc Vayssieres (DWR), and Dr. Janet Thompson (USGS).
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel:
Equipment: No equipment is required.
Deliverables and dates:
Comments:

***Field survey of Microcystis aeruginosa Bloom Biomass and Toxicity***
IEP 2007-079
Point person: Rich Breuer (DWR)
Lead Agency: DWR-DES, DFG
Questions: Is *Microcystis* biomass or toxicity increasing over time in the Delta? Does *Microcystis* bloom biomass or microcystins toxicity occur in areas important to pelagic fish



species in the Delta? Is there a relationship between bloom biomass and toxicity with zooplankton and fish abundance? Is there a relationship between the bloom biomass, microcystins in algal tissue or microcystins dissolved in the water column, and microcystins toxicity in zooplankton, benthic, epibenthic and fish tissue? Do regions of high zooplankton and benthic tissue microcystins toxicity coincide with high microcystin tissue content, lower density and poor health of planktonic feeding fish? Are dissolved microcystins produced during the decomposition phase of the bloom sufficiently toxic to impact fish and zooplankton survival and health based on densities at sampling stations and toxicity bioassays? What are the origins of the *Microcystis* blooms?
Description: Field surveys to measure *Microcystis aeruginosa* bloom biomass and toxicity. The 2006 surveys will build on the 2004-2005 survey and be closely coordinated with the fish surveys (TNS, FMWT) and toxicity assays. Sample collection at fish survey stations will help elucidate the link between *Microcystis* biomass and toxicity and its direct effect on zooplankton and fish. Water samples for *Microcystis* biomass and both algal tissue and dissolved microcystins toxicity will be collected monthly by DWR-DES staff at selected fish survey and zooplankton and fish toxicity assay stations, as well as stations with high *Microcystis* biomass identified in the 2004 survey. Zooplankton, benthos, and fish toxicity will be evaluated based on microcystin content in whole animal (zooplankton and benthic) or liver and muscle tissue (fish). Animals for these analyses will be collected during fish surveys. Epibenthic and benthic organisms will be collected by Ponar dredge or box sampler (C. Messer, personal communication) as a part of the bloom sampling effort or fish survey as appropriate. Environmental conditions associated with the bloom biomass and toxicity will be measured at each station with an YSI 6600 Sonde and by water samples for a suite of discrete water quality measurements including nutrient concentration. Qualitative observations of *Microcystis* surface blooms will be recorded by fish survey staff during all fish survey dates and at all sites.
Time period: Summer and fall 2006-2007.
Resources required
Cost: 250,000 from CBDA Prop 50 Science Program PSP.
PI(s): Peggy Lehman (DWR) and Dan Riordan (DWR).
Contract needed / in place: In place.
Contract manager:
Term of contract:
Personnel: This work would be conducted by redirected and additional hired temporary DWR-DES staff including a boat operator; microcystins toxicity analyses by Dr. G. Boyer at State University of New York.
Equipment:
Deliverables and dates:
Comments: Toxicity analysis will be done by Dr. G. Boyer of the State University of New York, an expert on cyanobacterial toxicity. His group has extensive experience in determination of cyanobacterial toxins and routinely analyzes samples for NOAA, CDC, and departments of health and conservation for several states. They also participated in the previous surveys. Future analyses may be possible at DFG's Water Pollution Control Laboratory.

***Analysis of historical population dynamics***
IEP 2007-084
Point person: Mike Chotkowski (USBR)

Lead Agency: USBR
Questions: The examination will extend the 2005 analysis of FMWT and Bay Study data to include other fish datasets, including the FWS JFMP seine dataset. This will include the evaluation and search of, (i) long-term trends, (ii) discernable epochs in the data, (iii) notable point or short-duration events, and (iv) coordinated or contemporaneous changes in multiple species that suggest a common explanation. We will also examine relevant historical data to evaluate historical support for the two "narrative" hypotheses developed in 2005.
Description: These investigations were a component of the 2005 investigations. Based on results to date, we believe continuation is warranted to complete work already started, complete work that could not begin in 2005 due to unavailable data, and to extend the investigation in ways intended to comport with reviewer recommendations.
Time period: Ongoing through 2007.
Resources required
Cost: The 2007 budget is $62,000 from POD sources. Some funds may be required for contracts with external parties in the future.
PI(s): Mike Chotkowski (USBR) and Dr. Bryan Manly
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Personnel other than the CO-PI's are not required.
Equipment: There is no field or lab equipment associated with this project.
Deliverables and dates: In 2006 we will submit at least two manuscripts for publication. One will be a methods paper dealing with the new regime change analysis developed by Bryan Manly; the other will be an account of the 2005 analysis of FMWT and Bay Study data, and what the findings imply.
Comments: Statistician Bryan Manly has agreed to assist. San Luis Delta Mendota Water District has generously agreed to support Dr. Manly's work. Other outside assistance may be required in the future.

***Power Plant Operations***
IEP 2007-087
Point person: Ted Sommer (DFG)
Lead Agency: DWR and others
Questions: What are the characteristics of the cooling water diversions associated with the Contra Costa and Pittsburg power plants, and what effects might they have on pelagic fishes? Have there been recent increases in pelagic fish entrainment?
Description: This study was previously a component of the 2005 work element, "Analysis/summary of recent changes in delta water operations". Based on the initial data review, we believed that the issue warranted a focused study. The purpose of this element is to closely examine power plant operations to identify whether there were effects strong enough to contribute to the long-term and recent apparent step change in pelagic fish abundances.
Time period: Ongoing through 2007.
Resources required
Cost: Any additional costs for agency work will be absorbed by existing DWR personnel.
PI(s): Randall Mager and Stephanie Sparr (DWR)
Contract needed / in place: N/A



Contract manager: N/A
Term of contract: N/A
Personnel:
Equipment:
Deliverables and dates:
Comments: Although we were unable to obtain detailed data on recent project operations and fish entrainment for the 2005 synthesis report, we have had new and promising contacts regarding power plant data.

**III. New studies**

***Contaminant loads in pelagic fish eggs***
IEP 2007-018
Point person: Randy Baxter
Lead Agency: DFG, UCD
Questions: Has there been a change in amount and/or type of contaminants contained in striped bass eggs since 1999.
Description: Striped bass are long-lived predatory fish with the potential to accumulate toxic materials either through food or across the gill surface. Their high fat content makes eggs likely physiological targets for toxic effects of fat-soluble contaminants. Unpublished work on egg and larval health of striped bass provides strong grounds for concern. This project will assess the contaminant load of striped bass eggs collected in 2005 and compare that to work done in 1999 and 2000 following the methods developed by David Ostrach. The shorter-lived smelt and shad are less likely to display "maternal gift" impacts, so this work focuses on striped bass. This work will complement and fit in with that described in element 2007-042.
Time period: Chemical analyses of archived samples will take place as soon as DFG water pollution lab can process the samples and analysis of the results will follow soon thereafter.
Resources required
Cost: $10,000 required to conduct this work was obtained in 2006.
PI(s): David Ostrach (UCD)
Contract needed / in place:
Contract manager: Ted Sommer (DWR)
Term of contract: See Element 2007-042.
Personnel:
Equipment:
Deliverables and dates: See Element 2007-042.
Comments:

***Preliminary investigations of disease as a factor in the POD***
IEP 2007-036
Point person: Randy Baxter (DFG)
Lead Agency: DFG, USFWS, and UCD
Questions: What are the incidences and severities of indicators of disease or parasites for each target fish species? What can be inferred from these data about the impacts of disease and parasites on POD fish populations?

Description:
Time period: In addition to the collection of striped bass and delta smelt for histopathology in 2006, sampling will be augmented to allow collection and as needed on-board processing of fresh specimens of all four target fishes for several time periods. Sampling will be repeated in 2007 with enhanced effort for some or all target species.
Resources required
Cost: $24,000 from POD sources.
PI(s): Scott Foot (USFWS)
Contract needed / in place: In place
Contract manager: Ken Lentz (USBR)
Term of contract:
Personnel:
Equipment:
Deliverables and dates:
Comments: This work is moderately feasible and will depend upon our ability to supply field crews at the proper time, coordinate field assistance with diverse PI's and collect sufficient specimens in a limited number of field days.

***Development of striped bass life cycle models***
IEP 2007-038
Point person: Ted Sommer
Lead Agency: UCD, SFSU-RTC, LSU, and consultants
Questions: What factors are the dominant drivers of striped bass population dynamics? What are the best management strategies for each of these species?
Description: Life cycle models are need for both striped bass and longfin smelt, but we will pursue a model for striped bass first. Significant information exists and for striped bass some existing models may be able to be modified to meet these purposes. Synthetic modeling capabilities are a very powerful means of evaluating the interactive influences of multiple stressors on fish population dynamics (Rose 2000).
Time period: 2006-2007
Resources required
Cost: $224,000 required to conduct this work was obtained in 2006 from POD sources.
PI(s): Frank Loge (UCD) and Kenny Rose (LSU)
Contract needed / in place: In progress
Contract manager: Ted Sommer (DWR)
Term of contract: TBA
Personnel:
Equipment:
Deliverables and dates:
October 2006 - 1st progress report and CALFED Science Conference presentation.
April 2007- 2nd progress report, IEP Newsletter article, and IEP Workshop presentation.
October 2007 - 3rd progress report and CALFED Science Conference presentation.
April 2007- 4th progress report, IEP Newsletter article, and IEP Workshop presentation.
June 2008 - Submission of 3 peer-reviewed manuscripts addressing description, calibration, hypothesis testing, and comparison of a) dose-structured population dynamics, b) IBM, and c) matrix models. Additionally, computer codes for each model and supporting documentation explaining use, inputs, and outputs.
Comments:



***Threadfin shad data analysis and population dynamics***
IEP 2007-039
Point person: Ted Sommer (DWR)
Lead Agency: DWR
Questions: What are the seasonal and spatial trends in threadfin shad abundance? What factors affect their abundance and distribution? Do salvage estimates seasonally or cumulatively appear related to the longer term relative abundance of threadfin shad?
Description: In 1959, threadfin shad were introduced into reservoirs in the Sacramento and San Joaquin drainages, and from these introductions the species expanded throughout the freshwater portions of the system. Little is known about their population dynamics within the delta and until about 2002 even their abundance trends were not regularly reported (e.g., their absence IEP Newsletter 2001 (2)). We propose to continue the examination of the distribution and abundance patterns of threadfin shad within the Delta and expand analyses to include investigation of fish entering from upstream.
Time period: 2006-2007
Resources required
Cost: $57,000 from POD sources.
PI(s): Fred Feyrer (DWR)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: 2 Scientific, 1 Environmental Scientist, and 1 boat operator are needed.
Equipment: Equipment: $1,000, Toxicity analysis: $20,000.
Deliverables and dates: Poster presentation at CALFED, October 2006; Oral presentation at IEP Annual Workshop, February 2007.
Comments: Substantial catch, length and distribution data exists in state and federal survey databases that can be used to address the study questions.

***Modeling the delta smelt population in the San Francisco Estuary***
IEP 2007-041
Point person: Randy Baxter (DFG)
Lead Agency: USGS, SFSU-RTC, LSU and consultants
Questions: What are the best management strategies for this species?
Description: This element is a CALFED Science PSP grant that will use three different modeling approaches for looking at delta smelt population dynamics.
Time period: 2006-2008
Resources required
Cost: $332,000 per year for 3 years. Total is $997,000.
PI(s):
Contract needed / in place:
Contract manager:
Term of contract: 3 years, beginning in 2006

Personnel:
Equipment:
Deliverables and dates:
Comments:

***Estimation of Pelagic Fish Population Sizes***
IEP 2007-043
Point person: Mike Chotkowski (USBR)
Lead Agency: DFG, DWR, USBR, consultants and contractors.
Questions: What are the most efficient regions (strata) for each target species sampled by the TNS, MWT and Kodiak surveys? Do fixed sampling stations in a highly tidal system approximate random distributions? What are the population sizes for each of the target pelagic species? Should strata variance be calculated based upon a normal distribution? What are the most efficient regions (strata) for each target species sampled by the TNS, MWT and Kodiak surveys? Do fixed sampling stations in a highly tidal system approximate random distributions? What are the population sizes for each of the target pelagic species? Should strata variance be calculated based upon a normal distribution or another type of distribution?
her type of distribution?
Description: Except for adult striped bass, the status of pelagic fish populations has primarily been assessed using relative abundance indices. IEP has been reluctant to translate these data into population sizes because of sampling selectivity (i.e., non-random site selection), gear efficiencies are unknown for each of the sampling programs and fish tend be patchy, likely adding substantial variability. Other approaches for pelagic fish population estimation are unreasonable (e.g., direct counts, mark-recapture, and change in ratio). However, the POD effort would benefit greatly from at least crude population estimates, allowing calculation of mortality rates and population modeling. The development of mean-density expansion estimators based upon stratified random trawl sampling represents the most practicable alternative. As initial steps to estimate population size, Bennett (2005) has used the TNS and MWT data, and Miller (2005) has analyzed the Kodiak trawl data. This element will build on those earlier efforts to develop population estimates for as many of the target pelagic species as possible. Refinements of their efforts may include the use of known salinity and temperature effects on target species distributions, updated bathymetry and the particle tracking models to: 1) post-stratify survey data (i.e., set more efficient region boundaries); 2) improve habitat volume estimates represented by fixed stations and regions for each of the surveys; and 3) test the assumption of randomness in the data.
Time period: Ongoing through 2007.
Resources required
Cost: $42,000 required to conduct this work was obtained in 2006 from POD sources.
PI(s): Ken Newman (USFWS)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Ken Newman (USFWS)
Equipment:
Deliverables and dates:



Comments: Although there are substantial obstacles to measurement of population sizes, the recent efforts of Bennett (2005) and Miller (2005) provide a reasonable foundation for future work.

***Zooplankton fecundity and population structure***
IEP 2007-044
Point person: Anke Mueller-Solger (DWR)
Lead Agency: SFSU-RTC
Questions: Has there been a downward shift in egg production and/or nauplius survival that resulted in lowered ratios of copepodites to adults? Has there been a change in copepodite survival?
Description: This is an analysis of *Pseudodiaptomus forbesi* and *Eurytemora affinis* life stage structure and fecundity from archived zooplankton samples (1996-2005) and associated water temperature data. The goals are to determine whether the recent increase in *Corbula* abundance was associated with an increase in mortality of sub-adult (i.e., copepodite stage) *P. forbesi* and *E. affinis*, and/or a reduction in adult *P. forbesi* and *E. affinis* fecundity.
Time period: 2006-2007
Resources required
Cost: $80,000 from POD sources.
PI(s): Wim Kimmerer
Contract needed / in place: In progress
Contract manager: Ted Sommer
Term of contract: Through December 30, 2008.
Personnel:
Equipment:
Deliverables and dates: See Element 2007-076.
Comments: Feasibility is high because the samples have already been collected and pilot work indicates the methods are appropriate to answer the study questions.

***Overlap/Synthetic analysis of POD data***
IEP 2007-046
Point person: Randy Baxter (DFG)
Lead Agency: USGS, DFG, DWR
Questions: Specific questions and working groups have not been determined at this time. More discussions with NCEAS members need to occur before determining the most valuable questions to pursue.
Description: The overall goal for the proposed NCEAS working groups is to conduct and/or guide the integration, analysis, and synthesis of POD and other relevant data and information in a more efficient, sophisticated, unbiased, and synergistic manner than would be possible with local resources alone. The focus of the NCEAS working group should be identification of and testing of hypotheses about individual and interacting stressor(s) associated with the observed POD trends, the linkages among these stressors, and the mechanistic pathways leading to the observed trends. Continuous analysis of POD data will help to examine overlap in space and time of pelagic species, food organisms, toxicants, toxic algae, and diversions. Effort will tie together and analyze field data, environmental data, operations information and information from otolith, histopathological and bioassays.

Time period:
Resources required
Cost: The 2007 POD budget for this element is $656,000; an additional $290,000 was already obtained in 2006 from POD sources.
PI(s): Larry Brown (USGS), and Gonzalo Castillo (USFWS)
Contract needed / in place: In process.
Contract manager: Kim Webb will manage the NCEAS contract.
Term of contract: Scientifically sophisticated approaches and defensible conclusions require substantial time. We envision the IEP/POD-NCEAS interaction to continue beyond the term of this contract and at this time would like to establish a working relationship through the end of 2008, with the possibility of an extension.
Personnel: Other key staff members include Fred Feyrer (DWR) and Randy Baxter (DFG).
Equipment:
Deliverables and dates: Fall 2007: Draft synthesis report authored by NCEAS POD working team members, perhaps with the help of an NCEAS postdoc. A comprehensive synthesis report would follow one year later. Additionally, scientific presentations and presentations geared at lay audiences would be authored by individual POD or NCEAS working group members.
Comments: Existing staff members from the above agencies are being redirected to work closely with NCEAS to participate in the synthesis of IEP data as it relates to the POD.

***Corbula salinity tolerance, distribution and grazing rates***
IEP 2007-076
Point person: Ted Sommer (DWR)
Lead Agency: DWR, USGS and SFSU
Questions: What is the salinity tolerance of *Corbula amurensis?* How well do salinity tolerances explain the distribution of *Corbula*? What are regional trends in benthos and grazing rates?
Description: A central part of the "Bad Suisun Bay Hypothesis" is that *Corbula* distribution has changed, perhaps in response to recent salinity increases during autumn. To better evaluate this hypothesis, we need to develop salinity tolerance information for the clam. This will be performed in a controlled laboratory setting, likely at SFSU Romberg Tiburon Center. To provide additional insight into the "Bad Suisun Bay Hypothesis", we need better fine-scale regional data on the distribution and grazing rates of benthic organisms. Towards this end, field surveys will be performed by EMP staff in 2006 and 2007. Two spatially intensive (~250 samples/event) surveys will be performed each year to assess the distribution, abundance, size (and therefore grazing rate) of benthic bivalves.
Time period: Mid-2006 through 2008.
Resources required
Cost: The 2007 POD budget is $65,000, however $117,000 is the total amount for laboratory studies of salinity tolerances through the contract period. No additional costs for the field surveys and data analyses.
PI(s): Jonathan Stillman and Wim Kimmerer (SFSU)
Contract needed / in place: In place
Contract manager: Ted Sommer
Term of contract: July 2006 through December 2008



Personnel: Key staff includes Marc Vayssieres and Karen Gehrts (DWR), Dr. Janet Thompson and Heather Peterson (USGS).
Equipment:
Deliverables and dates:
October 2007: Submit Year 1 progress report to IEP. This will be provided as one or more IEP Newsletter articles or manuscripts, depending on the results to date.
February 2008: Present preliminary results at Asilomar.
December 2008: Final reports, which will comprise draft manuscripts for submission to journals or the IEP Newsletter, as appropriate.
Comments:

***CASCaDE computational assessment of scenarios***
IEP 2007-081
Point person: Steve Culberson (CALFED)
Lead Agency: USGS
Questions: This study will establish a model-based approach for placing quantitative bounds on water resource and ecosystem responses to a plausible range of future changes in the Bay-Delta Rivers and Watershed system – critical information that will allow resource agencies to anticipate changes and develop flexibility in their strategic planning to accommodate those changes before they occur. While this project has broad relevance to many goals of the CALFED Science Program, it is most directly relevant to the third priority research topic identified in the 2005 Science Program PSP, which solicits "analytical frameworks that will support assessments and refined predictions of how likely future changes such as population or climate-related hydrological shifts may affect water operations, ecosystem processes, and CALFED projects".
Description: The goals of this project are to develop and apply a model-based approach of ecological forecasting (Clark 2001) to project future states of the Delta ecosystem under prescribed scenarios of change, and to communicate the outcomes of those scenarios to resource managers. Specific objectives include: 1) Develop/refine/calibrate/verify a set of mechanistic numerical models of climate, watershed hydrology, Bay-Delta hydrodynamics, sediments and geomorphology, and water quality; 2) Link these models to project system dynamics from prescribed forcings, beginning with the climate system (including sea level) and then cascading to the watershed (water, sediment, contaminant runoff), river system (flow, heat, sediment and contaminant transport), and Delta-Bay (hydrodynamics, water temperature, salinity, primary productivity, suspended sediments, geomorphology); 3) Compare projections under prescribed scenarios of within-Delta habitat change and catastrophic levee failures; 4) Apply model projections to assess changes in water and habitat quality, potential habitat expansion of key alien species (*Egeria, Corbicula, Potamocorbula*), incorporation of contaminants such as mercury and selenium into food webs, and qualitative population responses of native fishes, and; 5) Work in collaboration with CBDA agencies and interested stakeholders to develop flexible strategic plans based on a range of plausible, quantitative depictions of the Bay-Delta Rivers and Watershed system as it changes during the 21st century.
Time period: 2006-2008
Resources required
Cost: $554,000 per year. This is a CALFED Science PSP-funded study through contract with the USGS.
PI(s): Jim Cloern

Contract needed / in place: In place
Contract manager: Michelle Shouse
Term of contract: 3 years
Personnel:
Equipment:
Deliverables and dates:
Comments:

***Food-web support for delta smelt and estuarine fishes in Suisun Bay and upper Estuary***
IEP 2007-082
Point person: Steve Culberson (CALFED)
Lead Agency: SFSU-RTC
Questions: Within the Low-Salinity Zone of the northern estuary:
1. How do benthic grazing, available solar irradiance, and the concentrations of and composition of nitrogenous nutrients interact to influence the species composition and production of phytoplankton?
2. How does bacterial production respond to changes in particulate and dissolved organic carbon (POC & DOC) delivered primarily through river flow?
3. What is the role of the microbial food-web in supporting higher trophic levels?
4. To what extent is copepod production dependent on these alternative energetic pathways (phytoplankton and bacterial production)?
Description: This is a CALFED Science Program-funded study focused on two related topics:
Topic 1: The threatened delta smelt (*Hypomesus transpacificus*) is now the principal species of concern for management of freshwater flow and diversions in the Sacramento-San Joaquin Delta, and the principal target for restoration in the upper San Francisco Estuary. The abundance of this federally-listed threatened species has been low since the early 1980s, and it has not recovered to the point where it can be considered for delisting; indeed, the 2004 abundance index was the lowest on record. Potential reasons for its low abundance are many, but evidence points to the direct and indirect effects of export pumping of freshwater in the south Delta, toxic substances, and low food supply as likely contributing factors. We believe that the feeding environment of delta smelt may be implicated in the continued low abundance of this species. Delta smelt feed for their entire lives on zooplankton, principally copepods, mainly in the brackish waters of the western Delta and Suisun Bay. As outlined in the submitted proposal, copepod abundance is depressed in this region.
Topic 2: Previous work on the responses of the estuarine ecosystem to interannual variation in freshwater flow has demonstrated a decoupling between the abundance of lower trophic levels and that of fish and shrimp (Kimmerer 2002a, b, 2004). This decoupling may imply that variability in food-web support is unimportant to variability of higher trophic levels, but there are some important pieces missing from the puzzle. Chief among these is the fact that the supply of labile organic matter from freshwater to the LSZ varies with freshwater flow, and this flux has not been accounted for in analyses of the estuarine food-web.
The funded proposal includes efforts aimed at understanding and possibly improving the food-web supporting delta smelt and other estuarine species.
Time period: 2006-2008
Resources required
Cost: $390,000 per year. This is a CALFED Science PSP-funded grant.



PI(s): Wim Kimmerer
Contract needed / in place: This is a CALFED Science grant
Contract manager: Ladd Lougee
Term of contract: 3 years
Personnel:
Equipment:
Deliverables and dates:
Comments:

***Gear Efficiency Studies***
IEP 2007-086
Point person: Randy Baxter (DFG)
Lead Agency: DFG
Questions: What is the retention efficiency (fish in the net that remain held) of trawl nets and how does it vary by fish species and individual size? What is the capture efficiency of trawl nets for target species? With this information, can existing monitoring data be used to estimate fish population sizes?
Description: Trawl fishing gear is selective for fishes inhabiting open water or a relatively smooth bottom. In addition, trawl dimensions and mesh sizes affect the size of fishes enclosed and retained. We propose to review existing information, conduct data analyses and plan new experiments to show the effective retention size range(s) for fishes and estimated capture efficiencies of trawl nets currently used by DFG long-term fish monitoring. Review and planning will probably take most of 2006, and field experiments commence in 2007. One step was taken in September 2005 with the addition of a 1/8" mesh cover to the cod-end of the Fall Midwater Trawl (FMWT) net to document the sizes of fishes retained and of those that passed through the net during sampling. Concern about the additional cod-end material on the behavior of the net in the water (slower decent at deployment), lead to limited experimentation during 2005 FMWT sampling. We intend to develop field studies for 2007 to examine retention and capture efficiencies.
Time period: As time becomes available during 2007.
Resources required
Cost: $10,000 required to do this work was obtained in 2006.
PI(s): Staff time to complete this task has not been identified.
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Staff time to complete this task has not been identified.
Equipment:
Deliverables and dates:
Comments: The feasibility for this element is moderate for 2007 assuming improved staffing. Literature review can be accomplished with temporary personnel and some permanent time.

***Hydrologic changes and Suisun Bay Salinity***
IEP 2007-97
Point person: Ted Sommer (DWR)
Lead Agency: USGS

Questions: This work will investigate what hydrologic or climatic changes have resulted in increased fall salinity in the western Delta. Watershed events such as reservoir operations, rice field flooding, and sea level rise will be used to help answer this question.
Description:
Time period:
Resources required
Cost: The $62,000 required to conduct this work was obtained in 2006.
PI(s): Cathy Ruhl (USGS)
Contract needed / in place: In place
Contract manager: Erwin Van Nieuwenhuyse
Term of contract: N/A
Personnel:
Equipment: No equipment is required.
Deliverables and dates: A summary report has already been produced and a finalized report will be delivered in the second quarter of 2007.
Comments:

***SAV abundance and distribution***
IEP 2007-102
Point person: Bruce Herbold (EPA)
Lead Agency: USGS and UCD
Questions: Has Submerged Aquatic Vegetation (SAV) increased in the Delta? Has SAV altered the habitat to effect fish populations? Has SAV increased retention of suspended solids to create a less turbid environment, which is less hospitable to Delta Smelt?
Description: Using hyperspectral imagery, this project will provide annual acreage calculations of submerged aquatic vegetation (SAV) and quantify SAV regional distribution trends in the Delta for the past four years (2003-2006).
Time period: 2006-2008
Resources required
Cost: $204,000 required to conduct this work has already been obtained 2006.
PI(s): Susan Ustin (UCD) and Dave Schoellhamer (USGS)
Contract needed / in place: Yes
Contract manager: Ken Lentz (USBR) and Fred Feyrer (DWR)
Term of contract:
Personnel:
Equipment:
Deliverables and dates: Fall 2007-progress report as part of Fall 2007 Synthesis. Write up by February 2008.
Comments:

***Fish Facility History***
IEP 2007-107
Point person: Marty Gingras (DFG)
Lead Agency: DFG, USBR
Questions: What changes have occurred at the state and federal fish facilities that would change the reported number of salvaged fish?



Description: This project will identify changes that have occurred at the state and federal fish facilities from 1956 to 2006 that may have impacted the reported number of salvaged fish. However, this investigation will not report potential items that may have impacted the retention of fish in the holding tanks (holding tank screen size changes) or survival of fish once counted (debris loads in holding tanks and impacts on released fish).
Time period: 2006 and 2007
Resources required
Cost: The 2007 POD budget for this element is $26,000; an additional $26,000 required to complete this work was obtained already obtained in 2006 from POD sources.
PI(s): Jerry Morinaka (DFG) and Brent Baskerville-Bridges (USBR)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: 3 months of each PI's time, spread out over 6 – 9 months.
Equipment: No equipment is required for this analysis.
Deliverables and dates:
Comments:

***Delta smelt culture facility***
IEP 2007-108
Point person: Rich Breuer (DWR)
Lead Agency: UCD
Questions: Reliable supplies of all life stages of delta smelt are valuable to management and scientific communities for a number of reasons. Cultured delta smelt provide specimens with known rearing history, required for toxicological experiments; aids research and design of fish screen efficiency, and pre-screen losses; allows investigations into basic biology with application to wild populations; and enables the development of a formal delta smelt refugia population.
Description: This program will collect sub-adult broodfish via purse seine from the wild each year, and spawn and rear all life stages of delta smelt in the following year in accordance to the Delta Smelt Culture Manual (Baskerville-Bridges et al. 2005). Delta smelt would be housed and reared at the newly expanded Fish Conservation and Culture Laboratory (FCCL) located on Department of Water Resources (DWR) property near DWR's Skinner Fish Facility in Byron, CA.
Time period: This money will be used to produce F1 generation delta smelt from broodstock collected in December 2006.
Resources required
Cost: $165,000 from USBR Tracy operations, and $165,000 from POD sources.
PI(s): Drs. Raul Piedrahita, Joan Lindberg and Bradd Baskerville-Bridges
Contract needed / in place: Needed
Contract manager: Rich Breuer
Term of contract: TBD – Needs to be in place by July 1, 2007.
Personnel:
Equipment:
Deliverables and dates: 5,000 adults (>50mm) and 10,000 juvenile (20-50 mm) delta smelt specimens for 2007, and a Production Report.
Comments: A scope of work was submitted to IEP.

***Biomarkers Workshop***
IEP 2007-112
Point person: Rich Breuer (DWR)
Lead Agency: CALFED
Questions: Do biomarkers currently being evaluated for the pelagic organisms indicate a population level effect from stressors? Are current biomarker analyses techniques being used for POD adequate to discern the stressor source? C
Description: For the POD program, it is important to identify and apply biomarkers that can be applied to the fish species of concern, and help differentiate and quantify stressor groups. Not all biomarkers that are presently being explored in research labs fulfill these requirements, and careful consideration should be given to a work plan for future POD work involving biomarkers. A "Fish Biomarker Task Force" consisting of experts in this field would provide state-of-the-art information on biomarkers. This task force would examine and describe 1) available biomarkers according to a number of criteria including specificity and cost; 2) identify which biomarkers are applicable to Delta fish species of concern and what information they can provide; 3) identify research objectives and timelines for developing specific biomarker tools for Delta fish species of concern.
Time period: Summer 2007
Resources required: POD PI's conducting Biomarker work and solicited experts in biomarkers. CALFED would solicited experts and organize a workshop where currently applied Biomarker analyses for POD would be discussed, as well as emerging biomarker analyses and their applicability to Delta fish.
Cost: $13,000 (USBR → CALFED) required to conduct this work was already obtained in 2006.
PI(s): Steve Culberson (CALFED)
Contract needed / in place: In place.
Contract manager: Steve Culberson
Term of contract:
Personnel:
Equipment:
Deliverables and dates: Fall, 2007: Findings from task force on biomarker applicability to discern population level effect stressors in the Delta.
Comments:

***Striped bass bioenergetics evaluation***
IEP 2007-115
Point person: Ted Sommer (DWR)
Lead Agency: DWR and DFG
Questions: What are the trends in estimated population consumption demand of age-1 and older striped bass? Has age-1 and older striped bass consumption demand decreased more slowly than prey relative abundance/relative biomass?
Description: This element will couple bioenergetics analyses to data provided by element 2007-116 (Adult striped bass population dynamics) to estimate the long and short-term (i.e., POD years) trends in consumption demand of piscivorous striped bass.



Time period: Calendar year 2007; assuming the population demographic data are available in early 2007.
Resources required:
Cost: $23,000 for an Environmental Scientist 25% time.
PI(s): Marty Gingras (DFG)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Matt Nobriga and DFG staff to be determined.
Equipment: None required – this is a data mining/data analyses effort.
Deliverables and dates: Draft manuscript for publication by December 2007.
Comments:

***Adult striped bass population dynamics***
IEP 2007-116
Point person: Marty Gingras (DFG)
Lead Agency: DFG
Questions: What are the age-specific estimates of annual abundance, harvest rate, survival rate, and growth rate among striped bass aged >= 3 years?
Description: Estimate the age-specific annual abundance (including confidence intervals), harvest rate, survival rate, and growth rate among striped bass aged 3 years and older. Abundance will be estimated using a modified Peterson calculation, data from fish tagged during spring, and data from fish observed during a year-long creel survey. Ages will be determined primarily from interpretation of marks on scales known to be made annually but will be estimated using an age-length table as needed. Harvest rate will be determined using returns from a high-value reward tagging program. Survival rate will be determined from changes in the return-rate of tags from each of the two years following application of tags to a cohort and by analysis of the catch-curve of fish captured during tagging. Growth rate will be determined from mark-recapture data and from analysis of length-frequency distributions.
Time period: Through December 2007.
Resources required:
Cost: No increase over base budget.
PI(s): Kyle Murphy (DFG)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Kyle Murphy; Nina Kogut; Mike Harris; Mike Donnellan (DFG).
Equipment:
Deliverables and dates: An IEP Technical Report, an IEP Status and Trends article, and an IEP Quarterly Highlights submission.
Comments:

***Data mining for status and trends of predators***
IEP 2007-118
Point person: Larry Brown (USGS)
Lead Agency: USGS

Questions: Have populations of predators that prey upon pelagic fishes increased in recent years in either a relative (in relation to populations of other fishes) or an absolute (total number) sense?
Description: The questions about population sizes will mainly be address through summarization and integration of recent analyses of IEP data sets and possible some data analysis of other pertinent existing data. These data will be used by a companion study for the construction of an individual based bioenergetics model for striped bass and then applying the model to the striped bass population.
Time period: To be determined.
Resources required:
Cost: Remaining funding in a CALFED contract to L. Brown. Other analyses will be conducted with redirected staff effort.
PI(s): Larry Brown (USGS) and Fred Feyrer (DWR)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Brown and Feyrer
Equipment: N/A – this is a data mining effort.
Deliverables and dates: Progress report by November 2007
Comments:

***Delta Fish Biomass estimation***
IEP 2007-119
Point person: Ted Sommer (DWR)
Lead Agency: DWR and DFG
Questions: What are the trends in fish biomass in the San Francisco estuary? Are there specific changes in biomass that coincided with the POD years?
Description: The questions about biomass will mainly be address through summarization and integration of recent analyses of IEP data sets and possible some data analysis of other pertinent existing data. The work will largely be based on initial biomass estimates by Wim Kimmerer. The present study will update Wim's work through 2006.
Time period: Calendar year 2007.
Resources required:
Cost: This work will be conducted with redirected staff.
PI(s): Fred Feyrer (DWR) and Randy Baxter (DFG)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: Feyrer, Baxter, and Kimmerer
Equipment: N/A
Deliverables and dates: Progress report by November 2007.
Comments:

***Relationship between habitat and distribution***
IEP 2007-120
Point person: Bruce Herbold (USEPA)
Lead Agency: TBD



Questions: Have temporal-spatial shifts in the habitats required by pelagic fish reduced their likelihood of finding adequate amounts of different habitats? Have changes in the temporal-spatial distributions of habitats exposed them to new or more severe stressors?
Description: Habitat, as defined by studies of Feyrer and Nobriga of DWR, will be combined with physical data gathered throughout the estuary to allow GIS projections of suitable summer and fall habitats for delta smelt, threadfin shad and young of year striped bass. These habitats will be examined for several biologically important parameters: location, size, proximity to other habitat patches of the same sort, proximity to other sorts of habitat needed sequentially, and proximity to known or suspected sources of mortality or stress.
Time period: January through September 2007
Resources required:
Cost: $100,000 (very approximate) from POD sources.
PI(s): TBD
Contract needed / in place: Needed, unless this can be covered under existing contracts or redirected IEP staff.
Contract manager: TBD
Term of contract: TBD
Personnel: TBD
Equipment: None.
Deliverables and dates: Draft report by September 15, 2007. Final report by October 15, 2007.
Comments: This work can probably best be done by USGS personnel or by consultants working in concert with DWR personnel.

***In Situ Biomarker Study***
IEP 2007-121
Point person: Rich Breuer (DWR)
Lead Agency: *DWR/ EPA Office of Research and Development, Cincinnati Ohio*
Questions: Do fathead minnows exposed to the Sacramento and San Joaquin Rivers show evidence of endocrine disrupters?
Description: For the POD program, it is important to identify and apply biomarkers that can be applied to the fish species of concern, and help differentiate and quantify stressor groups. Not all biomarkers that are presently being explored in research labs fulfill these requirements, and careful consideration should be given to a work plan for future POD work involving biomarkers. EPA-ORD and the DWR EMP program will conduct two one-month studies in November 2006 and February 2007. Batches of Fat Head Minnows will be exposed in a flow through system to Sacramento and San Joaquin River water. The minnows will be processed and sent to ORD where they will be analyzed for endocrine disruptors. The tissue will be preserved and future biomarker work for Organo-phosphates and Pyrethroids.
Time period: Fall 2006 -Winter 2007
Resources required
Cost: Funding required for this element will be absorbed from existing program costs.
PI(s): Dan Riordan (DWR)
Contract needed / in place: Not needed
Contract manager: N/A
Term of contract: N/A
Personnel:

Equipment:
Deliverables and dates: Fall 2007, findings from analyses.
Comments: CALFED would solicited experts and organize a workshop where currently applied Biomarker analyses for POD would be discussed, as well as emerging biomarker analyses and its applicability for Delta fish.

***Food match mis-match***
IEP 2007-122
Point person: Randy Baxter (DFG)
Lead Agency: DFG
Questions: Are spring mesozooplankton densities and proximity to/overlap with larval delta smelt and striped bass related to feeding success, fish body condition and eventual recruitment? Do environmental factors – temperature, turbidity, and salinity – have an apparent role in feeding success?
Description: Larval growth-rate variability can influence recruitment by affecting the duration of early life stages -- those most vulnerable to predation (Houde 1996). Growth-rate in turn is influenced by feeding success (Margulies 1988), which may be mediated by the overlap of larva preferred temperature and salinity zones with areas of highest prey concentration (North and Houde 2001). Here we examine the relationships between the geographical distributions of food-sized zooplankton and larval delta smelt and larval striped bass in conjunction with water temperature, turbidity, salinity, and relate those to fish feeding success, body condition (relative weight at length) and recruitment (fall abundance indices). We use historical paired zooplankton and fish samples from tandem-fished Clark-Bumpus (CB; zooplankton) and 20 mm Survey (or Townet) nets to obtain organism densities and select fish for condition and stomach content measures.
Time period: 2007 - 2008
Resources required
Cost: No additional cost, redirected DFG staff will be used to accomplish this analysis.
PI(s): Steve Slater and John Budrick (DFG)
Contract needed / in place: N/A
Contract manager: N/A
Term of contract: N/A
Personnel: 3 laboratory staff for fish measurements and diet examination.
Equipment: Laboratory space, a balance and microscopes for length-weight measurements and diet examination.
Deliverables and dates: Tri-annual progress reports (April, August, December 2007); presentation Asilomar 2008, manuscript for submission to regional peer-reviewed journal summer 2008.
Comments: Personnel for this element have only recently (late fall 2006) become available. Sampling design and analyses have yet to be completely developed.

## Feasibility:



The IEP consists of individuals in institutions, agencies and companies uniquely qualified for this study effort. Our program combines the experience and expertise of staff and researchers at multiple agencies including CDWR, CDFG, USFWS, USGS, USBR, USEPA and UC Davis.

The 2006-2007 study components have been carefully selected based on their feasibility and potential to help differentiate among potential stressors. As demonstrated by the successful 2005 effort, the research team has extensive experience with all of the proposed methods and sampling locations. The proposed monitoring component is a slightly expanded version of sampling that has been conducted for many years, some of which comprises field work that has been performed for 30 to 45 years. Focused data analyses have been proposed as a study component because of the extent of the long-term data sets, and because of the relatively low cost and efficiency. The extensive studies conducted by other groups including Department of Waterways and the Regional Water Quality Control Board will be a major additional asset for the contaminant analyses. To perform the data analyses, only modest redirection of IEP staff will be required. Obviously, the ongoing studies represent a highly feasible study component as these efforts are already underway—they have already been peer-reviewed and have secured funding from IEP or CBDA. Finally, the proposed new studies are based largely on proven field and laboratory methods. Most of these studies are essentially an extension of pilot-scale or shorter-term efforts during the past five years. Examples include otolith studies and histopathology (Drs. Bennett, Hobbs and Teh for 1999 samples) and *Microcystis* surveys (Dr. Lehman for 2004).

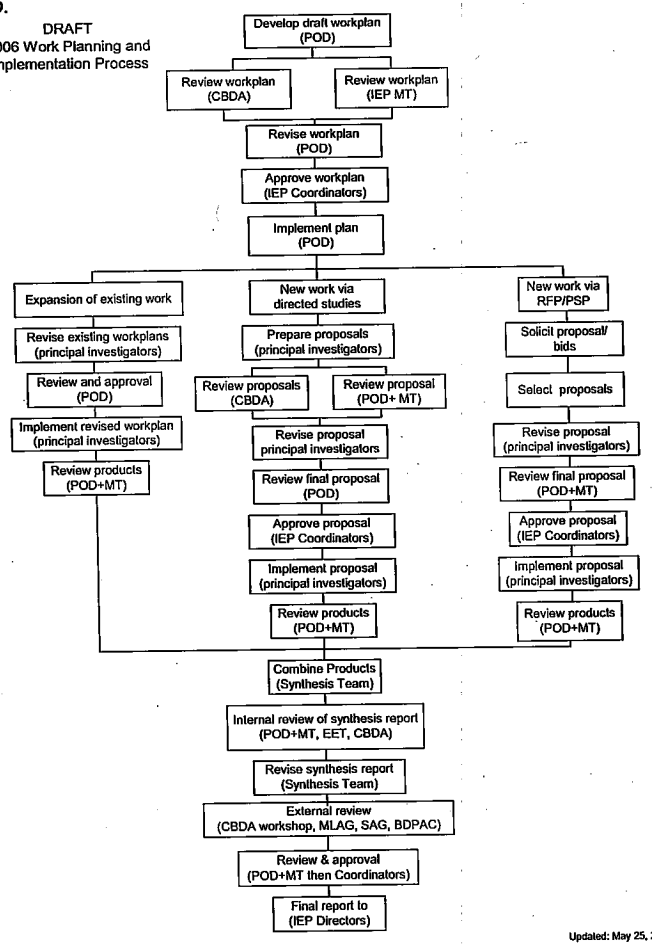
The studies will be completed using the existing Endangered Species Act "take" levels authorized by U.S. Fish and Wildlife Service and NOAA Fisheries. The expansion of sampling is relatively modest and should result in minimal change in "take" because smelt population levels are relatively low (i.e. low catch in sampling) and the sampling methods are unlikely to collect substantial numbers of winter- or spring-run Chinook salmon.

## Adaptive Management:

An annual and intra-annual adaptive work planning process will be used for the investigations into the observed decline of the pelagic guild (Figure 9). The work in 2006 was designed to look at the range of possible causative factors from a broad perspective in an effort to remove some from consideration and to focus future efforts in the most appropriate directions. The results of the 2006 work will be used to define and focus the efforts needed in subsequent years. For example, if the statistical analysis of historical trends suggests other species or time period should be considered, they will be added to the 2007 program. Actions considered for 2006 may also include changes in water project operations as an adaptive experiment to evaluate effects on entrainment or food web production. Similarly, there may also be recommendations for adaptive regional efforts to reduce contaminant load, reducing populations of exotic species, or increasing food web inputs (e.g. habitat restoration). This effort would likely be coupled with hydrologic and perhaps biological modeling to help screen the range of alternatives. Within any year as information is developed and evaluated, changes in emphasis and direction may be needed. The POD PWT will provide this oversight and evaluation function.

**Figure 9.**

DRAFT
2006 Work Planning and Implementation Process






## Project Management, Coordination, and Oversight:

The study is exceptionally complex, including multiple agencies, research topics and principal investigators. Responsive management, close coordination among study participants, and some degree of oversight by independent experts will be critical to the successful completion of the study. We propose the components summarized below for project management, coordination, and oversight. Similar models have been used for IEP and CALFED projects in the past. We hope this level of coordination and oversight will assure the success of this study without overly burdening project staff.

*Project Management Team:* The project will be managed by a collection of State and Federal agencies: Chuck Armor (DFG), Randall Baxter (DFG), Rich Breuer (DWR), Mike Chotkowski (USBR), Pat Coulston (DFG), Steve Culberson (CBDA), Bruce Herbold (EPA), Anke Mueller-Solger (DWR), Matt Nobriga (DWR) and Ted Sommer (DWR). As in 2005 and 2006, the group will typically meet weekly to evaluate the progress of the effort. This is the same group that prepared this study plan.

*POD Project Work Team:* Project design, coordination, and discussion of preliminary results will occur in the newly formed POD PWT. This is a proven model that has been used for a variety of different interdisciplinary IEP studies. This is intended as the primary forum for all principal investigators, and will also be open to other parties, including other regional experts, provided they are willing to actively contribute to the effort. The PWT would meet a minimum of every 2 months, with project management team members alternating as meeting chair. Satellite PWT's would also be formed to allow more intensive communication about technical areas (see below).

*POD PWT Satellite Teams:* We expect that the parent POD will be fairly large, making it difficult to have detailed discussions about each component. To provide an opportunity for more intensive communication and planning, at satellite project work teams have been formed: 1) food web (Wim Kimmerer); 2) Contaminants (Swee Teh); 3) water exports (Ted Sommer and Mike Chotkowski); 4) sampling (Bill Bennett); and 5) geographical variability (Rick Sitts). At least one additional satellite team is being considered to handle data management and analysis. The lead person(s) from each subject area will routinely be in contact with the appropriate principal investigators and will conduct subject area meetings with principal investigators as needed. Subject area e-mail reflectors may also be set up to further facilitate communications.

*Email reflector:* Much of the communication for the project would be conducted via a new POD PWT email reflector. The reflector would primarily be used for communication and coordination among the principal investigators; however, it may also be a useful outlet for other scientists who wish to contribute.

*Oversight:* Project oversight will be provided by the project management team, the POD PWT and an additional group of regional and national experts on the various aspects of this study. These scientists will be part of IEP Science Advisory Group (SAG), with additional support from CALFED and other agency science advisors. This "POD-Science" group will oversee the scientific soundness of this project and provide recommendations for improvement. This group is invited to attend any of the meetings mentioned above and receive e-mails via the newly

established list serves. Meetings with POD PWT members may be arranged as needed. In addition, the POD-Science group will meet in the end of each year to discuss project results, synthesis, and further studies with POD PWT members.

*Outreach:* Various products and deliverables (see below) will be completed as part of the project. Staff will give a presentation at the numerous conferences (see below) to describe the status of the fish decline and the efforts to identify causes. In addition, the POD PWT will organize an IEP workshop by late 2007 to present preliminary results. A substantial portion of the 2006 and 2007 IEP Annual Meetings will provide opportunities to update the results and present key information.

## Budget:

The initial cost estimate for 2007 is approximately $3,260,000. CALFED grants that directly support various POD efforts or that will supply information useful to the POD effort are estimated at $2,302,000 for 2007. Cost estimates for individual program components are provided in Table 2 and in the previous section as part of the project summaries. In some instances, money for 2007 work was obtained in 2006, therefore not reflected in the table below.

Table 2. 2007 POD Budget (amounts are in $1,000)

| | PEN[1] | POD Total | DWR POD | USBR POD | CALFED | Comments |
|---|---|---|---|---|---|---|
| **I. Existing Monitoring** | | | | | | |
| Summer Townet Survey | 7 | $23 | $23 | $0 | | |
| EMP - Water Quality Monitoring | 72 | $122 | $96 | $26 | | |
| Field support for additional work | 89 | $75 | $75 | $0 | | |
| Larval fish survey | 96 | $97 | $97 | $0 | | |
| **I. TOTAL for EXISTING MONITORING** | | $317 | $291 | $26 | $0 | |
| **II. Ongoing Work** | | | | | | |
| Delta and Suisun Bay particle tracking investigations | 31 | $49 | $49 | $0 | | |
| Delta smelt otolith geochemistry and stock structure | 40 | $76 | $0 | $0 | $76 | CBDA Science |
| Striped bass health investigations | 42 | $416 | $416 | $0 | | |
| Phytoplankton primary production and biomass in the Delta | 45 | $50 | $50 | $0 | | |
| Apparent growth rates of pelagic fish | 51 | $38 | $38 | $0 | | |
| Otolith analysis of delta smelt fish | 60 | $512 | $39 | $123 | $350 | CALFED-ERP |
| Liver histopathology for pelagic fish | 61 | $350 | $0 | $0 | $350 | CALFED-ERP |
| Fish diet and condition | 62 | $11 | $11 | $0 | | |
| Acute and chronic invertebrate and fish toxicity | 63 | $644 | $0 | $644 | | |
| Changes in pelagic fish habitat | 66 | $184 | $184 | $0 | | |
| Field survey of Microcystis bloom biomass and toxicity | 79 | $250 | $0 | $0 | $250 | CBDA Science |
| Analysis of historical population dynamics | 84 | $62 | $0 | $62 | | |
| **TOTAL for ON-GOING STUDIES** | | $2,480 | $787 | $829 | $1,026 | |
| **III. New Special Studies** | | | | | | |
| Preliminary investigations of delta fish diseases | 36 | $24 | $16 | $8 | | |
| Analysis of threadfin shad data | 39 | $57 | $57 | $0 | | |
| Modeling delta smelt population in the SF Estuary | 41 | $332 | $0 | $0 | $332 | |
| Estimation of pelagic fish population sizes | 43 | $0 | $0 | $0 | | |
| Zooplankton fecundity and population structure | 44 | $80 | $80 | $0 | | |
| Overlap analyses of fish, zooplankton, etc. and NCEAS | 46 | $656 | $96 | $560 | | |
| Corbula salinity tolerance, distribution and grazing rates | 76 | $65 | $65 | $0 | | |
| CASCaDE computational assessments of scenarios | 81 | $554 | $0 | $0 | $554 | CBDA Science |
| Foodweb support for delta smelt and estuarine fishes | 82 | $390 | $0 | $0 | $390 | CBDA Science |
| Gear efficiency studies | 86 | $0 | $0 | $0 | | |
| Fish facility history | 107 | $26 | $0 | $26 | | |
| Delta smelt culture facility | 108 | $165 | $165 | $0 | | |
| Biomarkers workshop and ORD study | 112 | $0 | $0 | $0 | | |
| Striped bass bioenergetics | 115 | $23 | $23 | $0 | | |
| Relationship between habitat and distribution | 120 | $100 | $50 | $50 | | |
| Statistical support | 123 | $0 | $0 | $131 | | |
| **TOTAL for NEW STUDIES** | | $2,472 | $552 | $644 | $1,276 | |

| | Overall POD | DWR POD | USBR POD | CALFED |
|---|---|---|---|---|
| **2007 POD TOTAL** | $5,562 | $1,630 | $1,630 | $2,302 |

## Products and Deliverables:

The monitoring and assessment program developed by this multi-institutional collaboration will yield a range of products and deliverables. The POD PWT oversight team above is responsible for the timely completion of all deliverables and serves as the principal contact for IEP staff and other stakeholder groups. The deliverables can be grouped into four general categories:

*Monitoring Data.* As in previous years, all data collected from the monitoring elements of this study program will be uploaded to the Bay Delta and Tributaries (BDAT) Project Site (http://bdat.ca.gov). BDAT contains environmental data concerning the San Francisco Bay-Delta and provides public access to that data. Over 50 organizations contribute data voluntarily to this project. The database includes biological, water quality, and meteorological data that are used to gauge the health of the estuary and to manage water and environmental resources. Also zooplankton, macroinvertebrate and fish monitoring data will be available directly via the web (http://www.delta.dfg.ca.gov).

*Conferences and Workshops.* The results of the study will be presented at a special session at the IEP Annual Workshop each year during 2006-2008. A special CDBA workshop will also be considered to discuss the project's final report. Several members of the program will also present their results at a special POD session at the spring 2006 American Fisheries Society meeting. Similar group presentations will be made at the CALFED Science conference (October 2006) and the State of the Estuary Conference (autumn 2007).

*Publications and Reports.* The researchers in this effort all place high value on the publication of peer-reviewed information. In 2005, the short timeline and management importance of the study effort limited our ability to produce journal articles. For 2006, we propose to submit a minimum of four articles to peer reviewed journals on: 1) analysis of trends in estuarine species (2 articles); 2) trends in physical habitat (1 article); 3) particle tracking results (1 article). By 2007, we propose to submit an additional 4-5 articles on diverse topics including regional analysis of factors affecting primary productivity (Jassby, UCD), toxic effects (e.g. Teh and Werner UCD), and food limitation (e.g. Bennett, Hobbs and Teh UCD). If appropriate, a feature article or collection of articles on the results of the overall effort will be submitted to the IEP Newsletter by winter 2007.



## References Cited

Arnold, J. D. and H. S. Yue. 1997. Prevalence, relative abundance, and mean intensity of pleurocercoids of *Proteocephalus* sp. In young striped bass in the Sacramento-San Joaquin Estuary. California Fish and Game 83: 105-117.

Bennett, W. A., D. J. Ostrach, and D. E. Hinton. 1995. Larval striped bass condition in a drought-stricken estuary: evaluating pelagic food web limitation. Ecological Applications 5: 680-692.

Bennett, W .A. 2005. Critical assessment of the delta smelt population in the San Francisco estuary, California. San Francisco Estuary and Watershed Science. Vol. 3, Issue 2 (September 2005), Article 1.
http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art1

Brown, L. R. and D. Michniuk. In review. Nearshore fish assemblages of the alien-dominated Sacramento-San Joaquin Delta, 1980-1983 and 2001-2003.

Brown, T. and K. Hieb. Introduction of the Siberian prawn Exopalaemon modestus to the San Francisco Estuary. California Fish and Game. Accepted manuscript.

Bryant, M. E. and J. D. Arnold. Diets of age-0 striped bass in the San Francisco Estuary, 1973-2002. California Fish and Game. Accepted manuscript.

CDPR Summary of Pesticide Use Report Data 2003. California Environmental Protection Agency, Department of Pesticide Regulation. 493p.

Carmichael, W. W., 1995. Toxic Microcystis in the Environment. In M. F. Watanabe, K. Harada, W. W. Carmichael and H. Fujiki (eds.). Toxic Microcystis. CRC Press, New York: 1-12.

Clark, J.S., and others. 2001. Ecological forecasts: an emerging imperative. Science 293: 657-660

Culberson, S. D., C. B. Harrison, C. Enright, and M.L. Nobriga. 2004. Sensitivity of larval fish transport to location, timing and behavior using a particle tracking model in Suisun Marsh, California. Pages 257-267 in F. Fryrer, L.R. Brown, R. L. Brown and J.J. Orsi editors. Early Life History of Fishes in the San Francisco Estuary and Watershed. American Fisheries Society, Symposium 39, Bethesda, Maryland.

Cushing, D. H. 1990. Plankton production and year-class strength in fish populations: an update of the match/mismatch hypothesis. Advances in Marine Biology 26: 249-288.

Dege, M. and L. R. Brown. 2004. Effect of outflow on spring and summertime distribution and abundance of larval and juvenile fishes in the upper San Francisco Estuary. Pages 49-66 in Feyrer, F., L. R. Brown, R. L. Brown, and J. J. Orsi (eds.). Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society Symposium 39.

Feyrer, F., B. Herbold, S. A. Matern, and P. B. Moyle. 2003. Dietary shifts in a stressed fish assemblage: consequences of a bivalve invasion in the San Francisco Estuary. Environmental Biology of Fishes 67: 277-288.

Grimaldo, L.F. 2004. Diet and carbon sources supporting fishes from open-water, edge and SAV habitats in restored freshwater wetlands of the San Francisco Estuary. Masters thesis, San Francisco State University.

Honey, K., R Baxter, Z. Hymanson, T. Sommer, M. Gingras and P. Cadrett (in prep). IEP long-term fish monitoring program element review. Interagency Ecological Program for the San Francisco Estuary Technical Report

Houde, E.D. 1996. Evaluation stage-specific survival during the early life of fish. pp. 51-66. In *Survival Strategies in Early Life Stages of Marine Resources*. Watanabe, Y., Yamashita, Y. and Oozeki, Y., eds. A.A. Balkema, Rotterdam.

IEP (Interagency Ecological Program for the San Francisco Estuary). 1987. Factors affecting striped bass abundance in the Sacramento-San Joaquin river system. Interagency Ecological Program for the San Francisco Estuary Technical Report 20.

IEP (Interagency Ecological Program for the San Francisco Estuary). 1995. Working conceptual model for the food web of the San Francisco bay/Delta estuary. Interagency Ecological Program for the San Francisco Estuary Technical Report 42.

IEP (Interagency Ecological Program for the San Francisco Estuary). 2005a. Interagency Ecological Program 2005 Work plan to Evaluate the Decline of Pelagic Species in the Upper San Francisco Estuary.

IEP (Interagency Ecological Program for the San Francisco Estuary). 2005b. Interagency Ecological Program Synthesis of 2005 Work to Evaluate the Pelagic Organism Decline (POD) in the Upper San Francisco Estuary. Available at: http://science.calwater.ca.gov/pdf/workshops/IEP_POD_2005WorkSynthesis-draft_111405.pdf

Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R. Schubel, and T. J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5: 272-289.

Jassby AD, Cloern JE. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Ecosystems 10:323-352.

Jassby, A. D., J. E. Cloern, and B. E. Cole. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47: 698-712.



Kimmerer, W. J. and J. J. Orsi. 1996. Changes in the zooplankton of the San Francisco Bay Estuary since the introduction of the clam *Potamocorbula amurensis*. Pages 403-424. *in* J.T. Hollibaugh, editor. San Francisco Bay: the ecosystem. Pacific Division of the American Association for the Advancement of Science. San Francisco, California, USA.

Kimmerer, W. J., J. H. Cowan, Jr., L. W. Miller, and K. A. Rose. 2000. Analysis of an estuarine striped bass (*Morone saxatilis*) population: influence of density-dependent mortality between metamorphosis and recruitment. Canadian Journal of Fisheries and Aquatic Sciences 57: 478-486.

Kimmerer, W. J., J. H. Cowan, Jr., L. W. Miller, and K. A. Rose. 2001. Analysis of an estuarine striped bass population: effects of environmental conditions during early life. Estuaries 24: 557-575.

Kimmerer, W. J. 2002a. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25: 1275-1290.

Kimmerer, W.J. 2002b. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages. MEPS 243: 39-55.

Kimmerer, W.J. 2004. Open water processes of the San Francisco Estuary: from physical forcing to biological responses. San Francisco Estuary and Watershed Science 2.

Kimmerer, W., S. Avent, S. Bollens, F. Feyrer, L. Grimaldo, P. Moyle, M. Nobriga, and T. Visintainer. 2005. Variability in length-weight relationships used to estimate biomass of estuarine fishes from survey data. Transactions of the American Fisheries Society 134:481-495

Kimmerer, W. J. Submitted. This is a placeholder for a paper in review submitted (to MEPS?) regarding changes in LSZ biomass following the Potamocorbula invasion.

Knudsen, D.L., and K.A.F. Urquhart. 1988. Striped bass health monitoring 1988 final report (California Department of Fish and Game, Sacramento, California).

Lehman, P. W. and S. Waller. 2003. Microcystis blooms in the Delta. Interagency Ecological Program for the San Francisco Estuary Newsletter 16: 18-19.

Lehman, P. W., G. Boyer, C. Hall, S. Waller and K. Gehrts. 2005. Distribution and toxicity of a new colonial *Microcystis aeruginosa* bloom in the San Francisco Bay Estuary, California. Hydrobiologia 541: 87-99.

Limburg, K. E., M. L. Pace and K. K. Arend. 1999. Growth, mortality and recruitment of larval *Morone* spp. In relation to food availability and temperature in the Hudson river. U.S. Fishery Bulletin 97:80-91.

Livingston, R. J., X. Niu, F. G. Lewis, III, and G. C. Woodsum. 1997. Freshwater input to a gulf estuary: long-term control of trophic organization. Ecological Applications 277-299.

Lott, J. 1998. Feeding habits of juvenile and adult delta smelt from the Sacramento-San Joaquin river estuary. Interagency Ecological Program for the San Francisco Estuary Newsletter 11(1): 14-19.

Ludsin, S. A., and D. R. De Vries. 1997. First-year recruitment of largemouth bass: the interdependency of early life stages. Ecological Applications 7: 1024-1038.

Margulies, D. 1988. Effects of food concentration and temperature on development, growth, and survival of white perch, *Morone Americana*, eggs and larvae, Fishery Bulletin 87: 63-72.

Matern, S.A., P.B. Moyle, and L.C. Pierce. 2002. Native and alien fishes in a California estuarine marsh: twenty-one years of changing assemblages. Transactions of the American Fisheries Society 131:797-816.

Mayfield, R. in prep.

Meng, L. and J. J. Orsi. 1991. Selective predation by larval striped bass on native and introduced copepods. Transactions of the American Fisheries Society 120: 187-192.

Miller, BJ. 2005. Estimating the population size of delta smelt using the Kodiak trawl data. August 12, 2005.

Moles. A. 1980. Sensitivity of parasitized Coho salmon fry to crude oil, toluene, and naphthalene. Transactions of the American Fisheries Society 109: 293-297.

Moreno, A. 2003. Jellyfish of the San Francisco Estuary. Interagency Ecological Program for the San Francisco Estuary Newsletter 16(2): 56-58.

Moyle, P.B., B. Herbold, D.E. Stevens and L.W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 121:67-77.

Nichols, F.H. J.K. Thompson and L.E. Schemel. 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis* 2. displacement of a former community. Marine Ecology Progress Series 66:95-101.

Nobriga, M. L. 2002. Larval delta smelt diet composition and feeding incidence: environmental and ontogenetic influences. California Fish and Game 88: 149-164.

Nobriga, M. L., F. Feyrer, R. D. Baxter, and M. Chotkowski. 2005. Fish community ecology in an altered river Delta: spatial patterns in species composition, life history strategies and biomass. Estuaries. 776-785.

North, E.W. and E.D. Houde. 2001. Retention of white perch and striped bass larvae: biological-physical interactions in Chesapeake Bay Estuarine Turbidity Maximum. Estuaries 24: 756-769.



Orsi, J. J. 1995. Food habits of several abundant zooplankton species in the Sacramento-San Joaquin Estuary. Interagency Ecological Program for the San Francisco Estuary Technical Report 41.

Rees, J.T. and C.L. Kitting. 2002. Survey of gelatinous zooplankton ("jellyfish") in the San Francisco Estuary: Initial field survey, annotated species checklist and field key. Interagency Ecological Program for the San Francisco estuary Technical Report 70.

Rockriver, A.K., 2004. Vertical distribution of larval delta smelt and striped bass near the confluence of the Sacramento and San Joaquin rivers. Pages 97-108 in Feyrer, F., L. R. Brown, R. L. Brown, and J. J. Orsi (eds.). Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society Symposium 39.

Rohrlack, T., K. Christoffersen, E. Dittmann, I. Nogueira, V. Vasconcelos, and T. Börner. 2005. Ingestion of microcystins by *Daphnia*: Intestinal uptake and toxic effects. Limnol. Oceanogr., 50(2): 440–448.

Rose, K.A. 2000. Why are quantitative relationships between environmental quality and fish populations so elusive? Ecological Applications 10:367-385.

Siegfried, C.A. 1982. Trophic relations of *Crangon franciscorum* Stimpson and *Palaemon macrodactylus* Rathbun: predation on the opossum shrimp, *Neomysis mercedis* Holmes. Hydrobiologia 898:129-139.

Sitts, R.M. and A.W. Knight. 1979. Predation by the estuarine shrimps *Crangon franciscorum* Stimpson and *Palaemon macrodactylus* Rathbun. Biological Bulletin 156: 356-368.

Sommer, T., R. Baxter, and B. Herbold. 1997. Resilience of splittail in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society 126: 961-976.

Stevens, D. E., and L. W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin River system. North American Journal of Fisheries Management 3:425-437.

Stevens, D. E., D. W. Kohlhorst, L. W. Miller, and D. W. Kelley. 1985. The decline of striped bass in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 114: 12-30.

Sweetnam, D. A. 1999. Status of delta smelt in the Sacramento-San Joaquin Estuary. California Fish and Game 85: 22-27.

Turner, J. L. and H. K. Chadwick. 1972. Distribution and abundance of young-of-the-year striped bass, *Morone saxatilis*, in relation to river flow in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society 101: 442-452.

US EPA, 2002. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. Fifth Edition

Werner I., Deanovic L.A., Connor V., De Vlaming V., Bailey H.C. and Hinton D.E. (2000). Insecticide-caused toxicity to *Ceriodaphnia dubia* (Cladocera) in the Sacramento-San Joaquin River Delta, California, USA. *Environmental Toxicology and Chemistry* 19(1): 215-227.

Weston, D. P., J. You, and M. J. Lydy. 2004. Distribution and toxicity of sediment-associated pesticides in agriculture-dominated water bodies of California's Central Valley. Environmental Science and Technology 38: 2752-2759.



# Appendix A

Annotations for the Species Matrix Models (Figures 3-7)

## Longfin Smelt

**Mismatch of larvae with food**

In winter-spring larvae are present throughout region (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.), but no feeding data are available. In summer-fall young fish are beyond larval stage.

**Reduced Habitat Space**

The longfin smelt has a strong X2 relationship (Jassby et al. 1995) and the 20 mm survey shows its distribution is centered on X2 (Dege and Brown 2004). There is evidence that habitat space can vary with X2 for delta smelt; this may also apply to longfin smelt (See POD 2005 Synthesis Report Appendix A: 2g, Feyrer et al; 2g, Nobriga et al.). Beyond the winter and spring larval period, habitat extends to marine waters (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.), so habitat limitation is less likely.

**Adverse Water Movement**

The increased amount of Sacramento River water pulled towards export facilities in winter (POD 2005 Synthesis Report Appendix A: 2h, Simi and Ruhl) could potentially increase false attraction to upstream migrating adults and the retention of their larvae. In north Delta and Suisun Bay, as well as summer and fall, fish are distributed away from major water project influence (POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.).

**Entrainment (Water Projects, Power Plants)**

In winter-spring adults and larvae are present throughout region (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al), and increased salvage has been observed during winter in recent years (See POD 2005 Synthesis Report Appendix A: 2h, Herbold et al.) In summer-fall young fish are beyond export facility influence. In addition, salvage rates are lower in wetter years, when survival is also higher (Jassby et al. 1995; Sommer et al. 1997). In Suisun Bay, effects from power plant operations are possible year-round (See POD 2005 Synthesis Report Appendix A: 2h, Matica and Sommer).

**Toxics Effects on Fish**

In winter-spring adults and larvae are present throughout region (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). The juvenile and adult population is located downstream (Suisun and farther) in summer and fall. However, there is no current information on direct toxicity or histopathological evidence of toxicity.

**Toxics Effects on Fish Food Items**

Copepods and larger crustaceans are present throughout range of longfin (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). Results to date, for summer only, indicate that toxicity to standard organisms (*Ceriodaphnia dubia* and *Hyalella azteca*) was sporadic in space and time (see POD 2005 Synthesis Report Appendix A: 3e, Werner).

**Harmful Microcystis Bloom**
There is no likely impact from *Microcystis* due to mismatch of summer algal blooms in the south and central Delta and longfin smelt habitat, which extends from the north Delta through central San Francisco bay at that time (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.; 3d, Lehman et al.).

***Corbula* Impacts on Food Availability**
*Corbula* reduces availability of zooplankton (Kimmerer and Orsi 1996), which may have declined in Suisun Bay and the west Delta with a recent rebound in clam abundance and distribution. Kimmerer (2002b) reported a step change in longfin smelt abundance following the introduction of *Corbula*. However, *Corbula* is still only abundant in Suisun Bay (See POD 2005 Synthesis Report Appendix A: 3g, Vayssieres and Peterson). Lower grazing rates are suspected to occur in winter.

**Disease and Parasites**
There is a plausible impact everywhere longfin smelt are present and throughout the year (POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.), but no current information on disease or parasites.



## Delta Smelt

**Mismatch of larvae with food**
In spring larvae are present throughout region (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.) with some feeding data available (Nobriga 2002). In other months young fish are beyond larval stage.

**Reduced Habitat Space**
There is evidence that habitat space can vary with X2 for delta smelt, but it does not show a strong relationship with abundance or a time trend (See POD 2005 Synthesis Report Appendix A: 2g, Feyrer et al; 2g, Nobriga et al.). There is some evidence that south Delta habitat has degraded seasonally (DFG, unpublished data); however, this is a long-term pattern (e.g. 1940s).

**Adverse Water Movement**
The increased amount of Sacramento River water pulled towards export facilities in winter (POD 2005 Synthesis Report Appendix A: 2h, Simi and Ruhl) could potentially increase false attraction to upstream migrating adults and the retention of their larvae. In north Delta and Suisun Bay, as well as in mid summer through fall, fish are distributed away from major water project influence (POD 2005 Synthesis Report Appendix A: 2a, Baxter et al).

**Entrainment (Water Projects, Power Plants)**
In winter-spring adults and larvae are present throughout region (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al), and increased salvage has been observed during winter in recent years (See POD 2005 Synthesis Report Appendix A: 2h, Herbold et al.) In Suisun and north Delta, young fish are beyond export facility influence. In addition, salvage rates are lower in wetter years (Sommer et al. 1997). In Suisun Bay, effects from power plant operations are possible year-round (See POD 2005 Synthesis Report Appendix A; 2h, Matica and Sommer).

**Toxics Effects on Fish**
Adults and larvae are present throughout region during winter-spring but the juvenile population is distributed away from central and south Delta in summer and fall (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). A single ambient water toxicity test in 2005 failed to show an impact to juvenile delta smelt (See POD 2005 Synthesis Report Appendix A: 3e, Werner), but limited histopathology analysis showed liver lesions, potentially indicators of toxics exposure (See POD 2005 Synthesis Report Appendix A: 3b, Teh).

**Toxics Effects on Fish Food Items**
Copepods are present throughout range of delta smelt (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). Results to date for summer only indicate that toxicity to standard organisms (*Ceriodaphnia dubia* and *Hyalella azteca*) is sporadic in space and time (see POD 2005 Synthesis Report Appendix A: 3e, Werner).

**Harmful Microcystis Bloom**
There is no likely impact from *Microcystis* due to mismatch of dense summer algal blooms in the south and central Delta and delta smelt habitat, which extends from the north Delta through

Suisun Bay at that time (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.; 3d, Lehman et al.).

***Corbula* Impacts on Food Availability**
Sweetnam (1999), Bennett (2005) and Souza et al. (POD 2005 Synthesis Report Appendix A: 2b) report a decrease in size of delta smelt following the introduction of *Corbula*. Similarly, Teh (POD 2005 Synthesis Report Appendix A: 3b) reports a chronic depletion in liver glycogen levels, possibly a result of food limitation. *Corbula* reduces availability of zooplankton (Kimmerer and Orsi 1996), which may have declined in Suisun Bay and the west Delta with a recent rebound in clam abundance and distribution. However, *Corbula* is still only abundant in Suisun Bay (See POD 2005 Synthesis Report Appendix A: 3g, Vayssieres and Peterson). Lower grazing rates are suspected to occur in winter.

**Diseases and Parasites**
There is a plausible impact everywhere delta smelt are present and throughout the year (POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.), but no information on disease. A very low incidence of macroscopic internal parasites was detected in the 50 delta smelt examined in 2005 (POD 2005 Synthesis Report Appendix A: 3c, Gartz).



## Threadfin Shad

**Mismatch of larvae with food**
In summer larvae are present throughout region except Suisun Bay (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.), but no feeding data are available. In other months young fish are beyond larval stage.

**Reduced Habitat Space**
Threadfin shad are present everywhere, but less abundant in Suisun Bay (see POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.), but no information was developed on habitat trends or criteria.

**Adverse Water Movement**
Present everywhere (see POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). Mechanism unknown, but hydrodynamic effects likely regionally limited to central and south Delta

**Entrainment (Water Projects, Power Plants)**
Adults and larvae are present throughout region (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). Increased salvage has been observed during winter in recent years (See POD 2005 Synthesis Report Appendix A: 2h, Herbold et al.). However, north Delta is likely outside of entrainment influences. Threadfin shad are less abundant in Suisun, where effects from power plant operations possible year round (See POD 2005 Synthesis Report Appendix A; 2h, Matica and Sommer).

**Toxics Effects on Fish**
**Adults and juveniles** are throughout region, but less abundant in Suisun Bay (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). There is no current toxicology or histopathology information.

**Toxics Effects on Fish Food Items**
Copepods and cladocerans are present throughout range of threadfin shad (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). Results to date for summer only indicate that toxicity to standard organisms *Ceriodaphnia dubia* and *Hyalella azteca*) was sporadic in space and time (see POD 2005 Synthesis Report Appendix A: 3e, Werner).

**Harmful Microcystis Bloom**
Dense blooms are present in south and central delta during summer and fall, when threadfin larvae, juveniles and adults are also present, posing a plausible impact (See POD 2005 Synthesis Report Appendix A: 2a Baxter et al.; 3d, Lehman et al.).

***Corbula* Impacts on Food Availability**
There are no likely impacts at anytime. There is little distributional overlap between threadfin shad and *Corbula*. (POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.; 3g, Vayssieres and Peterson).

**Diseases and Parasites**

There is a plausible impact everywhere longfin smelt are present and throughout the year (POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.), but little current information on disease and parasites. A very low incidence of skin lesions was observed for threadfin shad in 2005 (POD 2005 Synthesis Report Appendix A: 3c, Gartz).



## Striped Bass

**Mismatch of larvae with food**
In spring and summer larvae are present throughout region (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.), with some feeding data available (Bennett et al. 1995; Bryant and Arnold, In press). In other months young fish are beyond larval stage.

**Reduced Habitat Space**
Striped bass survival has a strong X2 relationship (Jassby et al. 1995) and 20 mm survey shows its distribution is centered upstream of X2 (Dege and Brown 2004). However, X2 has no time trend (Kimmerer 2002a). There is evidence that habitat space can vary with X2 for young striped bass, but it does not show a strong relationship with abundance or a time trend during summer and fall (See POD 2005 Synthesis Report Appendix A: 2g, Feyrer et al; 2g, Nobriga et al.).

**Adverse Water Movement**
Increased amount of Sacramento River water pulled towards export facilities in spring and summer (POD 2005 Synthesis Report Appendix A: 2h, Simi and Ruhl) could potential increase the retention of eggs and larvae. Sacramento River flow can also affect transport of eggs and larvae. Flows in the Sacramento River were relatively low in winter and spring of 2001, but increased during subsequent years (POD 2005 Synthesis Report Appendix A: 2h, Simi and Ruhl). In Suisun Bay, fish are away from major water project influence (POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.).

**Entrainment (Water Projects, Power Plants)**
**Striped bass are** present throughout region at all times (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al), and increased salvage ahs been observed during winter in recent years (See POD 2005 Synthesis Report Appendix A: 2h, Herbold et al.). Jassby et al. (1995) found that exports may help to explain variability in striped bass survival. In Suisun Bay, effects from power plant operations are possible year-round (See POD 2005 Synthesis Report Appendix A: 2h, Matica and Sommer).

**Toxics Effects on Fish**
**Juveniles are** present throughout region at all times and larvae in late spring-summer (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). Although earlier work showed some evidence of larval toxicity (Bennett et al. 1995), a pair of ambient water toxicity tests for striped bass in 2005 failed to show an impact to juveniles (See POD 2005 Synthesis Report Appendix A: 3e, Werner).

**Toxics Effects on Fish Food Items**
Copepods, larger crustaceans and small fishes are present throughout range of striped bass (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). Results to date for summer only indicate that toxicity to standard organisms *Ceriodaphnia dubia* and *Hyalella azteca*) was sporadic in space and time (see POD 2005 Synthesis Report Appendix A: 3e, Werner).

**Harmful Microcystis Bloom**

Dense blooms are present in south and central Delta during summer and fall, when juvenile striped bass also present, posing a plausible impact (See POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.; 3d, Lehman et al.).

***Corbula* Impacts on Food Availability**

*Corbula* reduces availability of zooplankton (Kimmerer and Orsi 1996), which may have declined in Suisun Bay and the west Delta with a recent rebound in abundance and distribution. A diet shift and decrease in abundance of striped bass occurred following the introduction of *Corbula* (Feyrer et al. 2003; Bryant and Arnold, in press; DFG unpublished data). However, *Corbula* is still only abundant in Suisun Bay (See POD 2005 Synthesis Report Appendix A: 3g, Vayssieres and Peterson). A lower grazing rate is suspected to occur in winter.

**Diseases and Parasites**

There is a plausible impact everywhere striped bass are present and throughout the year (POD 2005 Synthesis Report Appendix A: 2a, Baxter et al.). Recent evidence of disease and parasites has been found in young bass (POD 2005 Synthesis Report Appendix A: 3c, Gartz; 3h, Ostrach; Arnold and Yue 1997).

# Attachment 15

# Multidecadal trends for three declining fish species: habitat patterns and mechanisms in the San Francisco Estuary, California, USA

**Frederick Feyrer, Matthew L. Nobriga, and Ted R. Sommer**

**Abstract:** We examined a 36-year record of concurrent midwater trawl and water quality sampling conducted during fall to evaluate habitat trends for three declining fish species in the San Francisco Estuary, California, USA: delta smelt (*Hypomesus transpacificus*), striped bass (*Morone saxatilis*), and threadfin shad (*Dorosoma petenense*). Generalized additive modeling revealed that Secchi depth and specific conductance were important predictors of occurrence for delta smelt and striped bass, while specific conductance and water temperature were important for threadfin shad. Habitat suitability derived from model predictions exhibited significant long-term declines for each species; the southeastern and western regions of the estuary exhibited the most dramatic changes. Declines in habitat suitability were associated with anthropogenic modifications to the ecosystem. For delta smelt, an imperiled annual species endemic to the estuary, the combined effects of fall stock abundance and water quality predicted recruit abundance during recent years of chronically low food supply. Our results are consistent with existing evidence of a long-term decline in carrying capacity for delta smelt and striped bass and demonstrate the utility of long-term data sets for evaluating relationships between fish and their habitat.

**Résumé :** Nous avons examiné des données concomitantes d'échantillonnage au chalut en pleine eau et d'échantillonnage de la qualité de l'eau faites à chaque automne pendant 36 années dans l'estuaire de San Francisco, Californie, É.-U., afin d'évaluer les tendances de l'habitat chez trois espèces de poissons en déclin, soit l'éperlan du delta (*Hypomesus transpacificus*), le bar rayé (*Morone saxatilis*) et l'alose fil (*Dorosoma petenense*). Un modèle additif généralisé montre que la profondeur de Secchi et la conductance spécifique sont d'importantes variables explicatives de la présence de l'éperlan du delta et du bar rayé, alors que la conductance spécifique et la température de l'eau le sont pour l'alose fil. Les prédictions du modèle indiquent une diminution significative à long terme de la qualité de l'habitat pour chaque espèce; les régions du sud-est et de l'ouest de l'estuaire montrent les changements les plus spectaculaires. Le déclin de la qualité de l'habitat est associé à des modifications anthropiques de l'écosystème. Chez l'éperlan du delta, une espèce annuelle, menacée et endémique à l'estuaire, les effets combinés de l'abondance des stocks à l'automne et de la qualité de l'eau expliquent l'abondance du recrutement durant les années récentes de sources de nourriture chroniquement limitées. Nos résultats confirment les indications existantes d'un déclin à long terme du stock limite de l'éperlan du delta et du bar rayé; ils démontrent l'utilité des banques de données couvrant de grandes périodes pour l'évaluation des relations entre les poissons et leur habitat.

[Traduit par la Rédaction]

## Introduction

There have been worldwide declines in production and yield of many estuarine-dependent fishes resulting from overfishing, pollution, and habitat alterations (Houde and Rutherford 1993). These trends have coincided with substantial long-term changes in fish species composition and abundance in developed North American estuaries (Matern et al. 2002; Hurst et al. 2004). Declining yields and changing fish communities suggest that current understanding of fish population dynamics is insufficient to ensure proper management.

The processes underlying fish population dynamics are complex because multiple interacting factors contribute to interannual variation in recruitment and abundance. A fundamental component in the study of population dynamics is the interaction between fish and their habitat. In the broadest sense, habitat can be characterized as the abiotic and biotic factors that are required to support healthy fish populations (Hayes et al. 1996). The abiotic components of habitat often strongly influence the biotic components, particularly in estuaries where freshwater inputs and associated salinity effects are important community-structuring mechanisms (e.g., Bulger et al. 1993; Jassby et al. 1995). Quantifying

Received 24 July 2006. Accepted 6 February 2007. Published on the NRC Research Press Web site at cjfas.nrc.ca on 11 May 2007.
J19439

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 doi:10.1139/F07-048 © 2007 NRC Canada

fish–habitat relationships and long-term trends in habitat suitability is critical because abiotic habitat components can affect the population dynamics of fishes in most habitat types (e.g., Cardinale and Arrhenius 2000; Claramunt and Wahl 2000; Rose 2000). Here, we use the term environmental quality (EQ; Rose 2000) to describe abiotic habitat variables that may affect fish population dynamics.

Long-term data sets are essential for the development and evaluation of fish–EQ relationships and time trends (Bray 1996; Rose 2000). Long-term data sets that include a wide range of environmental conditions are particularly useful because they allow researchers to more effectively model the linkages between EQ and fish occurrence (Rose 2000). Moreover, analyses of long-term data sets are needed to understand the effects of management actions. If rehabilitation is desired, then management actions aimed at improving EQ to a pre-existing state can often be determined from existing data. One limitation of empirical data, however, is that it frequently focuses on a particular life stage or time period when sampling was conducted. Thus, it is important to understand the temporal relevance of the sample collections in subsequent model development (Levin and Stunz 2005).

In this study, we quantified fish–EQ relationships in San Francisco Estuary (Fig. 1) using a long-term record (1967–2004) of fish and water quality data concurrently collected during fall (September–December). Our objectives were to (1) develop models relating fish occurrence to EQ, (2) examine temporal and spatial trends in EQ, and (3) determine whether the water quality variables that define EQ can also be linked to fish abundance. Understanding fish–EQ linkages is a principal goal in fisheries science and is of great practical interest in San Francisco Estuary. The estuary is well known for anthropogenic modifications that have highly altered most natural elements of the system, and there have been long-standing concerns about the effect of these modifications on fish populations (Nichols et al. 1986; Bennett and Moyle 1996). Indeed, many fish species have exhibited declines in abundance since long-term monitoring began in the 1950s (e.g., Stevens et al. 1985; Moyle et al. 1992). In recent years, there has also been an apparent step-decline in the abundance of three pelagic species — delta smelt (*Hypomesus transpacificus*), striped bass (*Morone saxatilis*), and threadfin shad (*Dorosoma petenense*) (Fig. 2). These species are the focus of our study. Concern is perhaps greatest for delta smelt, a rare and delicate endemic species listed as threatened under both the California and US Endangered Species Acts; a petition is currently being considered to downgrade delta smelt status to endangered. Water management actions in the estuary are closely tied to protecting delta smelt, even on a daily basis during some portions of the year. Management actions in the estuary receive great attention throughout the state because water diversions from the estuary supply drinking water to over 22 million people in California, in addition to supporting a multibillion dollar agricultural industry. Striped bass and threadfin shad are both introduced species; because they comprise a substantial portion of fish biomass in the ecosystem and support valuable recreational fisheries, their declines are also cause for concern.

## Materials and methods

### Study area

San Francisco Bay (Fig. 1) forms the largest estuary on the Pacific coast of the United States. The estuary is a drowned river valley separated into different basins by complex bathymetry. Water enters the estuary primarily from California's two largest rivers — Sacramento (from the north) and San Joaquin (from the south) — which drain a 100 000 km$^2$ watershed encompassing 40% of California's surface area. The rivers converge in the upper estuary to form the Sacramento – San Joaquin Delta, a 3000 km$^2$ network of tidal freshwater channels. From the delta, water flows west into Suisun Bay, through the Carquinez Strait, and enters San Pablo Bay before reaching San Francisco Bay and ultimately the Pacific Ocean. Owing to the Mediterranean climate, freshwater flow entering the estuary varies seasonally, occurring mainly in late winter through spring. The estuary is also subject to extreme interannual variation in freshwater flows, with periodic droughts and floods.

Anthropogenic modifications in this highly altered estuary include the loss of wetlands via draining and diking for agriculture, channel modifications for flood control and navigation, and a variety of water reclamation activities, including storage, conveyance, and large-scale water diversion from the southern delta (Nichols et al. 1986). Major dams located on the Sacramento and San Joaquin rivers, including most of their major tributaries, control flows entering the estuary. One result of these modifications is that water movement through the estuary is highly managed. Through the many large upstream dams; smaller, within-estuary flow control structures; and large water diversion operations in the southern delta, managers have an unparalleled ability to control water movement in the system. One of the ways in which flows are managed in this estuary is to benefit fishes and other organisms by manipulating the position of the estuarine salinity gradient.

Similar to most estuaries, many of the ecosystem components and functions of the San Francisco Estuary exhibit measurable responses to flow (Stevens and Miller 1983; Jassby et al. 1995; Kimmerer 2002). In particular, the abundance or survival of many fishes and invertebrates exhibits a strong relationship with flow entering the estuary, as indexed by the position of the 2‰ isohaline (Jassby et al. 1995; Kimmerer 2002). This index, termed $X_2$, is defined as the distance (km) from the Golden Gate Bridge to the location in the estuary where mean bottom salinity is 2‰ (Jassby et al. 1995; Kimmerer 2002). The position of $X_2$ is seasonally variable based primarily on river flow variation. However, its position can be manipulated and is closely managed to be located in certain regions during specific times of the year to benefit aquatic species.

### Data sources and analytical methods

We analyzed long-term data collected from a fall midwater trawl survey (FMWT) conducted by the California Department of Fish and Game (Stevens and Miller 1983). The survey has been conducted each year since 1967, except that no sampling was done in 1974 and 1979. The FMWT collects a sample (10- to 12-minute tow) at 100 sites four

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**Fig. 1.** Map of the San Francisco Estuary (California, USA) showing fall midwater trawl survey sampling stations. The location of the State Water Project (SWP) and Central Valley Project (CVP) export pumping facilities are also shown.

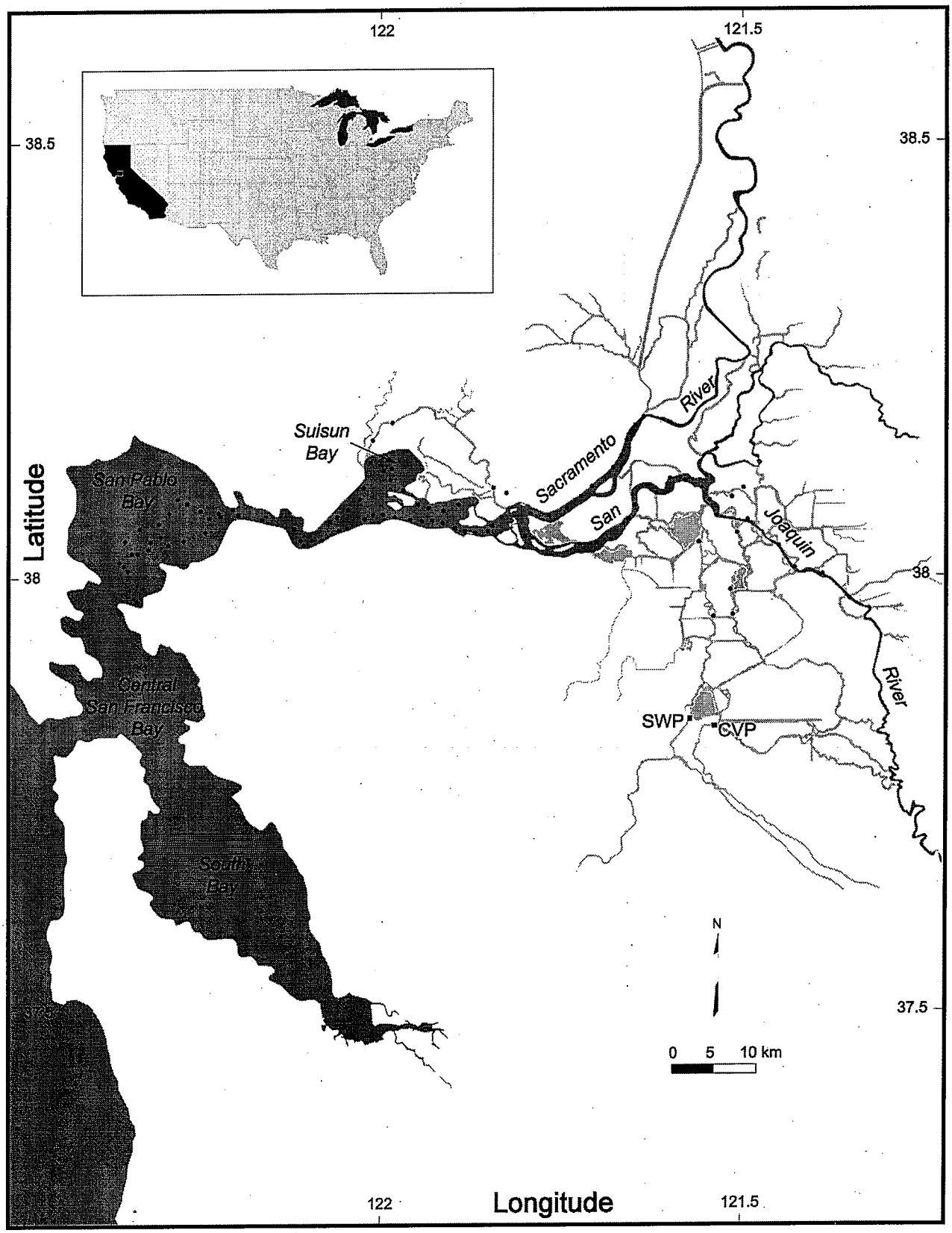


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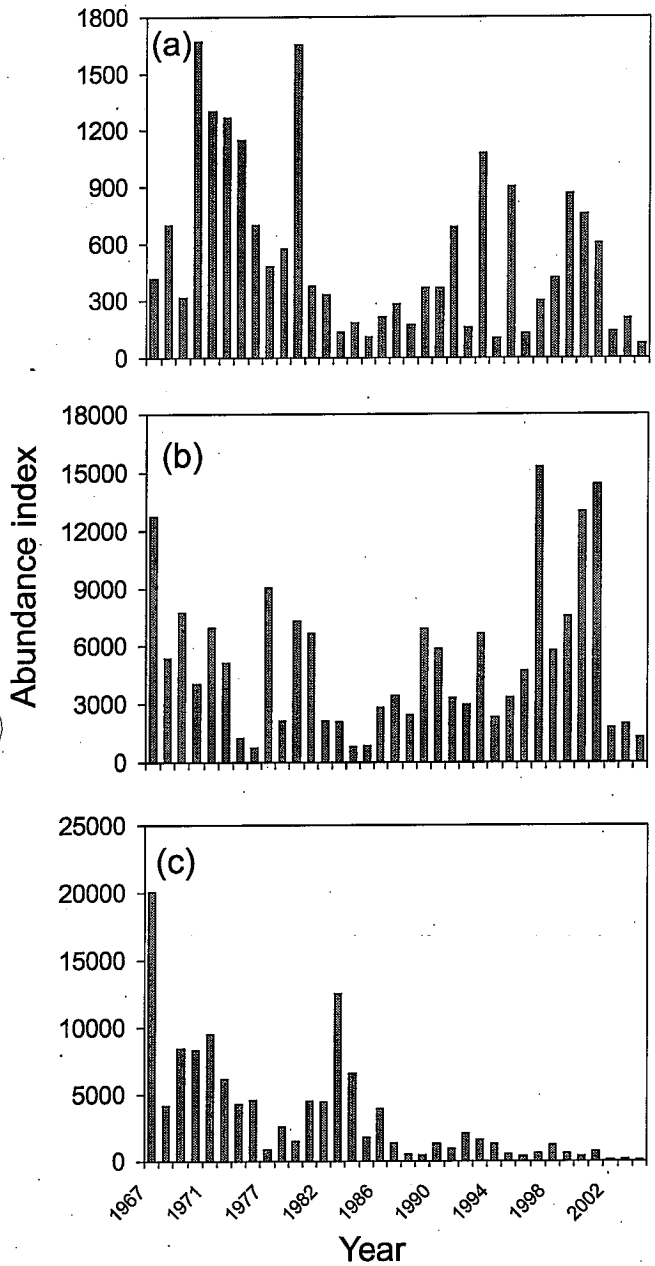
**Fig. 2.** Time series of abundance indices for (*a*) delta smelt (*Hypomesus transpacificus*), (*b*) threadfin shad (*Dorosoma petenense*), and (*c*) striped bass (*Morone saxatilis*) for the fall midwater trawl survey.




times per year — each month from September to December throughout the freshwater to mesohaline portions of the upper estuary (Fig. 1). The FMWT was originally designed to index the abundance of age-0 striped bass, which is reflected in the dimensions of the net: 17.6 m long with a mouth opening of 3.7 $m^2$ and nine tapered panels of stretch mesh from 14.7 to 1.3 cm in the cod end (Stevens and Miller 1983). The FMWT data have been used extensively in analyses of striped bass and delta smelt population dynamics (Turner and Chadwick 1972; Stevens et al. 1985; Moyle et al. 1992). Our analysis focused on age-0 striped bass, delta smelt, and threadfin shad, for which the FMWT is most efficient at capturing. The FMWT stations encompass the distribution of these species and life stages in the estuary. Delta smelt have been observed at 85% of the stations, while striped bass and threadfin shad have been observed at every station. Similar to many river-dominated estuaries, inflow to the system varies substantially from year to year. Thus, while the position of the sampling sites remains consistent, water quality varies interannually, which shifts the center of distribution of the fishes (Dege and Brown 2004). Three water quality variables — temperature (°C), Secchi depth (m), and specific conductance ($\mu S \cdot cm^{-1}$) — were measured concurrent with each tow, providing a 36-year time series (12 109 samples) of fish and environmental data (Fig. 3).

The FMWT data set provided a uniquely long time series to quantify fish occurrences in relation to water quality. For study objective 1, we used generalized additive models (GAMs) to describe these relationships (Norcross et al. 1997; Stoner et al. 2001). GAMs are semiparametric extensions of generalized linear models that are effective for describing nonlinear relationships between predictor and response variables (Guisan et al. 2002). GAM techniques are data-driven; they do not presuppose a particular relationship between predictor(s) and response variables. Rather, they employ smoothers to characterize the empirical relationships between predictor and response variables (Guisan et al. 2002). Link functions are used to establish relationships between the response variable and a smoothed function of the predictor variables; we used the cubic spline as our smoothing technique in the S-Plus language (Venables and Ripley 1997). Similar to previous studies (Maravelias 1999; Stoner et al. 2001), we used a binomial GAM with logit link function to relate fish occurrence to log-transformed environmental variables. A binary response (fish presence or absence, i.e., occurrence) was used instead of fish abundance to minimize the influence of outliers (i.e., extremely anomalous abundance values) and bias associated with previously reported abundance declines through time. We assumed that habitat preference was constant and that fish would continue to be present under preferred habitat quality conditions, albeit possibly in increasingly lower numbers. We modeled each species separately. Based on our knowledge of the range of each species and laboratory physiology studies (Swanson et al. 2000), we expected that each species would exhibit a unimodal occurrence probability to salinity and temperature and a declining occurrence probability to increasing Secchi depth. We assessed the statistical significance of the GAM results with a $\chi^2$ approximation that tests the ability of each explanatory variable to reduce the null deviance in the model (Venables and Ripley 1997).

The GAM analyses generated predicted occurrence probabilities for each species in each sample. We used these capture probabilities as an indicator of habitat suitability through time, which we defined as EQ (study objective 2). We visually evaluated long-term spatial variation in annual trends throughout the estuary using maps created with ArcMap geographic information system (GIS) software (ESRI, Redlands, California). Employing ordinary least squares, we linearly regressed the EQ data for the three fish species at each of the 100 stations against year and used the magnitudes of the slopes to examine long-term EQ trends among sampling stations and across regions of the estuary.

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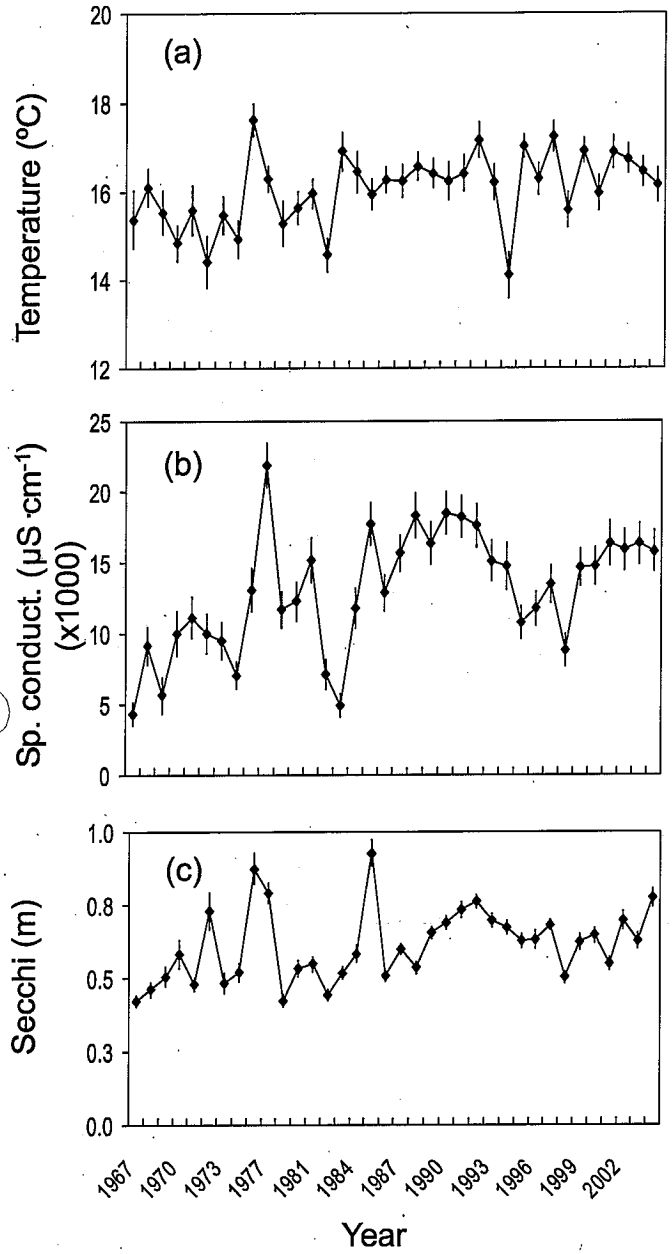
**Fig. 3.** Time series of (*a*) water temperature, (*b*) specific conductance, and (*c*) Secchi depth for the fall midwater trawl survey. The average and variation based on two standard errors are shown for each variable.




This approach generated 300 separate linear regressions. We incorporated the regression results into GIS maps by scaling GIS polygons representing surface area estimates for each sampling station (R. Baxter, California Department of Fish and Game, 4001 North Wilson Way, Stockton, California, unpublished data) by the corresponding regression slope. This procedure allowed us to create a continuous grid of the water surface area of the estuary with individual cells (polygons) scaled (by color shading) according to the slope coefficients for each species.

Lastly, we tested the ability of the water quality variables that composed EQ to predict delta smelt abundance (study objective 3). We limited this analysis to delta smelt because it is an annual species. The longevity of striped bass and threadfin shad makes modeling the effects of abiotic factors on abundance markedly more complex and beyond the scope of this paper (e.g., Kimmerer et al. 2001). Further, recent stock–recruit modeling supports the possibility of density dependence for delta smelt (Bennett 2005). In that study, Bennett (2005) hypothesized that a shrinking volume of physically suitable habitat combined with a high density of competing planktivorous fishes were the primary factors contributing to the decreasing carrying capacity for delta smelt. Our analysis was designed to test the hypothesis that the combined effects of fall stock abundance and fall water quality affect recruit abundance the following summer. We compared eight simple stock–recruit models to evaluate this hypothesis. Comparing the relative fit of models with differing conceptual interpretations is generally superior to simply examining the fit of any single model (Hilborn and Mangel 1997). The abundance indices we used for these models were derived by the California Department of Fish and Game and are available at www.delta.dfg.ca.gov/. Similar to previous studies (Moyle et al. 1992; Bennett 2005), we used the FMWT abundance index as an estimate of fall stock abundance and the Summer Townet abundance index as an estimate of summer recruit abundance. The basic model was a simple linear regression of adult stock versus recruit abundance. The other models included fall stock abundance and various combinations of mean annual fall Secchi depth or specific conductance in multiple regressions.

We separated the time series into two segments for this analysis: 1968–1986 and 1987–2004. This separation delineates a major ecological change in the food web of the estuary stemming from the invasion of the clam *Corbula amurensis* (Kimmerer 2002). Intense filtering of the water column by large populations of this clam essentially eliminated phytoplankton blooms in the lower estuary and caused major declines in the abundance of most planktonic invertebrates, including copepods, which are the primary prey of delta smelt (Kimmerer and Orsi 1996; Moyle 2002). Separation of the two time periods allowed us to examine the role of water quality when food was relatively abundant versus when it was not.

We compared the models in each time series by traditional means (level of statistical significance and comparison of $r^2$ values), but also evaluated the relative fit of each model with an information-theoretic approach based upon Akaike's information criterion (AIC; Burnham and Anderson 1998). This technique allows for a comparison of models with varying numbers of parameters and is based upon a strength-of-evidence context rather than traditional statistical tests of null hypotheses. Candidate models were evaluated based upon AIC, $\Delta_i$, and $w_i$ (Burnham and Anderson 1998): $\Delta_i$ (AIC differences) provides a level of empirical support for each model and is evaluated in relative rather than in absolute terms (values of 0–2 provide substantial support for a given model (0 being best), 4–7 considerably less support, and >10 virtually no support); $w_i$ provides a relative weight of evidence in support of a given model with the largest value being best. We further evaluated the fit of the regression models by visually examining residual plots for homogeneity of variance and used the Anderson–Darling test to determine if the residuals were normally distributed.

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**Table 1.** Generalized additive modeling results.

| Model | Species | | |
|---|---|---|---|
| | Delta smelt (*Hypomesus transpacificus*) | Striped bass (*Morone saxatilis*) | Threadfin shad (*Dorosoma petenense*) |
| Temperature (T) | 11 805 (0.1) | 16 542 (0.4) | 14 285 (4.4) |
| Secchi depth (S) | 10 295 (12.9) | 14 356 (13.6) | 14 748 (1.3) |
| Specific conductance (C) | 9 620 (18.6) | 14 928 (10.1) | 13 066 (12.5) |
| T + S | 10 250 (13.3) | 14 290 (14.0) | 14 125 (5.4) |
| T + C | 9 537 (19.3) | 14 893 (10.3) | 12 608 (15.6) |
| S + C | 8 856 (25.1) | 13 549 (18.4) | 12 874 (13.8) |
| T + S + C | 8 780 (25.7) | 13 460 (19.0) | 12 387 (17.1) |

**Note:** Residual deviance and percentage of total deviance explained (in parentheses) are given for each model. Null deviance is 11 822 for delta smelt, 16 608 for striped bass, and 14 935 for threadfin shad. The variables in each model were all statistically significant ($P < 0.0001$) based on approximate $\chi^2$ tests.

## Results

### GAMs

For each species, we found that all three environmental variables were statistically significant predictors of fish occurrence (Table 1). The global model, which included all three water quality variables, accounted for 25.7%, 19.0%, and 17.1% of total deviance in the models for delta smelt, striped bass, and threadfin shad, respectively (Table 1). Relationships between predicted occurrence (based on the global model) and individual water quality variables generally matched our expectations for Secchi depth and specific conductance, but not for water temperature (Fig. 4). Predicted occurrence of each species decreased as Secchi depth increased. Predicted occurrence of striped bass and delta smelt peaked at relatively low values along the specific conductance gradient, whereas for threadfin shad it exhibited a gradual negative relationship. There was no clear trend in the predicted occurrence of striped bass with temperature. For delta smelt, predicted occurrence was highest at the lowest temperature, and for threadfin shad it was highest at the lowest and highest temperatures. The addition of temperature to the GAMs for striped bass and delta smelt did not appreciably improve the amount of the deviance explained (0.4% for striped bass and 0.1% for delta smelt; Table 1). Hence, we concluded that a GAM including Secchi depth and specific conductance was the most appropriate for generating annual EQ trends for further analysis for these species. For threadfin shad, Secchi depth accounted for only 1.3% of the deviance; thus we selected temperature and specific conductance as a final model for threadfin shad.

### Trends in EQ

Overall, EQ values were highest for striped bass, intermediate for threadfin shad, and lowest for delta smelt, reflecting both their relative abundance and distributional range in the estuary (Fig. 5). There was an overall negative trend in EQ for each species, with delta smelt and striped bass exhibiting the most apparent declines. The declines in EQ appeared to be most apparent following the mid 1980s. Long-term spatial patterns in EQ (Fig. 6) were generally similar across species in that a high percentage of stations exhibited statistically significant ($P < 0.05$) declines: threadfin shad (64% of stations), delta smelt (63% of stations), and striped bass (65% of stations). There was only one instance of a station exhibiting a statistically significant increase in EQ; it was near the confluence of the Sacramento and San Joaquin rivers for delta smelt. The western and southeastern regions of the estuary exhibited the most substantial long-term declines in EQ for striped bass and delta smelt, as indicated by consistently steeper negative slopes and statistically significant regressions. The lower Sacramento River exhibited virtually no significant EQ changes for any species. For delta smelt, there were also some nonsignificant regressions for stations in the lower San Joaquin River. The southeastern region of the system exhibited few EQ changes for threadfin shad.

### Water quality – delta smelt abundance linkages

The results of the regression modeling support the hypothesis that water quality was an important predictor of delta smelt abundance during the 1987–2004 post-*Corbula* period (Table 2). None of the 1968–1986 pre-*Corbula* regression models were statistically significant ($P > 0.05$). However, all 1987–2004 post-*Corbula* models were statistically significant ($P < 0.02$). The residuals from these significant models were normally distributed (Anderson–Darling $P$ values $\geq 0.05$) and exhibited no apparent trend with the fitted values, suggesting the models adequately fit the data. A comparison of the $r^2$ values suggested that the stock + specific conductance model and the stock + specific conductance + Secchi depth model produced similar results (~60% of variance explained) and were superior in that they accounted for ~30% more variance than the other models. The AIC results also suggested that these two models provided similar fits to the data set and were superior to the other models (Table 2).

## Discussion

Understanding fish–habitat relationships is a fundamental step in characterizing EQ, as well as the effects of habitat manipulations on EQ, and ultimately, fish populations. In this study, we used statistical and graphical techniques to establish and evaluate EQ for selected fishes in the San Francisco Estuary. Our ultimate goal was to determine if changes in the water quality variables that defined EQ could have contributed to declines in fish abundance. Our approach was relatively novel in that most similar studies have been of much shorter duration and have been used merely to identify, not further analyze, fish–EQ relationships (Norcross et

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**Fig. 4.** Generalized additive model (GAM) predictions of fish occurrence (based on all three water quality variables) versus the observed individual water quality parameters ((*a*) water temperature, (*b*) Secchi depth, (*c*) specific conductance) for threadfin shad (*Dorosoma petenense*) (black triangles), delta smelt (*Hypomesus transpacificus*) (black circles), and striped bass (*Morone saxatilis*) (gray circles).

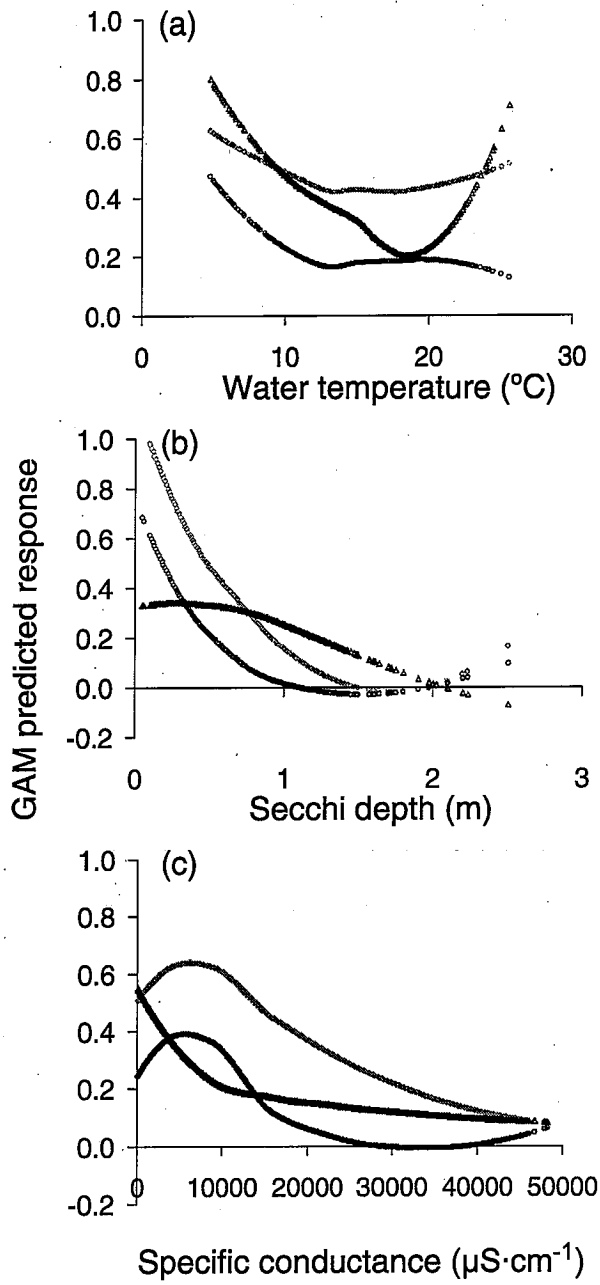
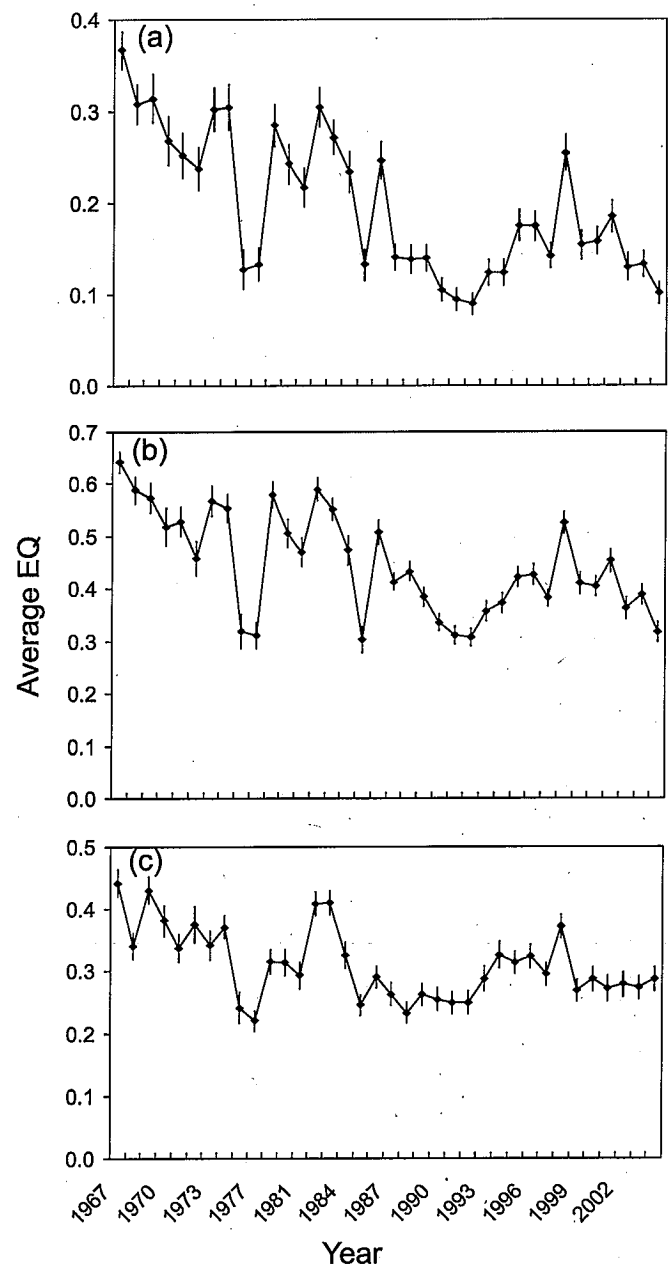



**Fig. 5.** Environmental quality (EQ) time series for threadfin shad (*Dorosoma petenense*), delta smelt (*Hypomesus transpacificus*), and striped bass (*Morone saxatilis*). The average and variation based on two standard errors are shown for each species.




al. 1997; Stoner et al. 2001). Whereas these previous studies sometimes used GAM results to make inferences about the likelihood of fish occurrence at new or unsampled locations, the extensive temporal (36 years) and spatial (100 stations) coverage of the FMWT survey afforded us an unusual opportunity to examine multidecadal trends throughout the estuary and in multiple geographic locations.

The first objective in our study was to relate fish occurrence to water quality variables to establish EQ for the three investigated species. We found that Secchi depth and specific conductance were important factors explaining the occurrence of delta smelt and striped bass, while specific conductance and water temperature were important for threadfin shad. Our GAMs using all three variables reduced null deviance between 17% and 26%, levels comparable with other studies (Maravelias 1999; Stoner et al. 2001). The GAM analysis results are consistent with information about the life history of each species. Delta smelt and age-0 striped bass are low-salinity zone specialists (Turner and Chadwick 1972; Moyle et al. 1992), and threadfin shad are mostly confined to freshwater zones, so it is reasonable to expect specific conductance to affect their occurrence. For delta smelt,

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**Fig. 6.** Spatial distribution of long-term trends in annual environmental quality (EQ) for (*a*) delta smelt (*Hypomesus transpacificus*), (*b*) threadfin shad (*Dorosoma petenense*), (*c*) striped bass (*Morone saxatilis*) in San Francisco Estuary shown for the region bordered downstream at Carquinez Strait. Color shading represents the coefficient for the year term for individual linear regressions of EQ versus year for each station. Lighter shading represents a more negative slope. Open circles and solid circles represent stations with nonsignificant ($P \geq 0.05$) or significant regressions ($P < 0.05$), respectively.

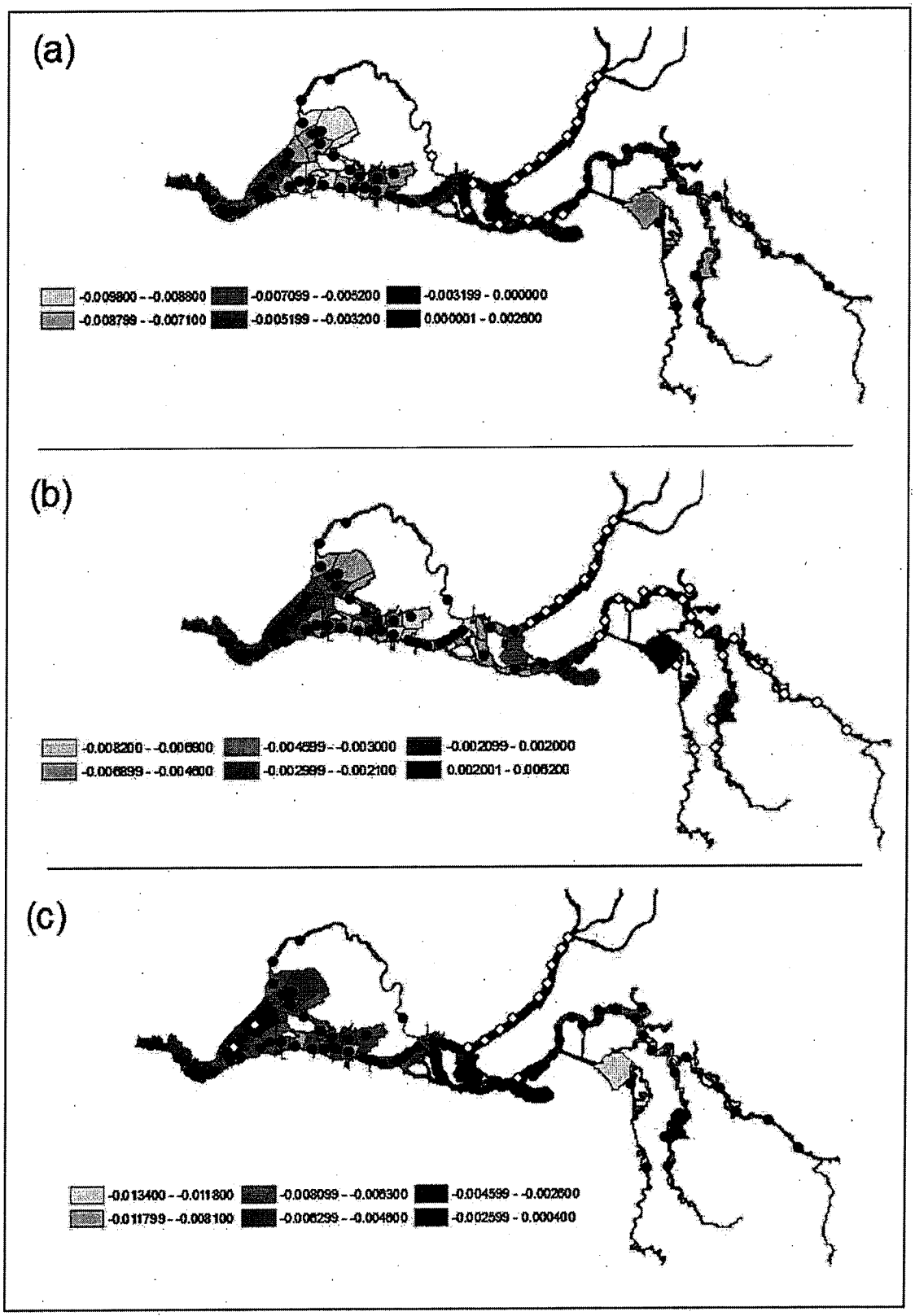


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**Table 2.** Regression statistics for various stock–recruit models for delta smelt (*Hypomesus transpacificus*) for the 1987–2004 post-*Corbula* time period.

| Fall stock | Specific conductance | Secchi | Constant | df | $P$ | $r^2$ | AIC | $\Delta_i$ | $w_i$ |
|---|---|---|---|---|---|---|---|---|---|
| 0.0078 | — | — | 1.5 | 16 | 0.005 | 39.5 | 96.08 | 6.0 | 0.003 |
| 0.0067 | –0.00068 | — | 12.3 | 15 | 0.001 | 59.6 | 90.08 | 0.0 | 0.06 |
| 0.0076 | — | –7.9 | 6.7 | 15 | 0.018 | 41.6 | 97.4 | 7.3 | 0.002 |
| 0.0068 | –0.00069 | 1.6 | 11.5 | 14 | 0.0004 | 59.6 | 92.8 | 2.7 | 0.02 |

**Note:** The same models were developed for the 1968–1986 pre-*Corbula* time period but are not shown because none were statistically significant ($P > 0.05$). The dependent variable for all regression models was the delta smelt recruit abundance index, as measured by the Summer Townet Survey. Candidate models were developed based on the possible combinations of the fall stock abundance index, with average fall values of specific conductance and Secchi depth as independent variables. Akaike's information criterion (AIC), AIC differences ($\Delta_i$), and AIC weights ($w_i$) are also shown.

our results are consistent with laboratory studies on their physiological tolerances to salinity (Swanson et al. 2000). Because delta smelt require turbidity for successful feeding (Baskerville-Bridges et al. 2004) and because predation is mediated by turbidity, it is possible that long-term increases in Secchi depth may have affected feeding success and predation pressures.

Factors affecting fish distribution often interact along spatial and temporal gradients (Jackson et al. 2001). Thus, it is critical to understand their spatiotemporal trends (study objective 2). The long-term EQ trends showed similar declines for each species across a broad geographical range. However, the steepest declines and highest levels of statistical significance occurred in the western, eastern, and southern regions. These results suggest that the lower Sacramento River has exhibited the least long-term habitat alteration as compared with the rest of the estuary, at least with respect to the evaluated abiotic factors. For delta smelt, there was some evidence that EQ had not declined as substantially in the lower San Joaquin River, suggesting that EQ in the region just upstream of the confluence of the Sacramento and San Joaquin rivers has remained relatively stable for delta smelt.

The spatial and temporal trends in EQ can largely be explained by an interaction of climate variability and anthropogenic factors. The increase in Secchi depth during the study period is primarily a function of a decline in total suspended solids, one of the long-term effects of upstream dam construction (Jassby et al. 2002). Wright and Schoellhamer (2004) documented that sediment transport to the estuary from the Sacramento River has declined by 50% since 1957. Nobriga et al. (2005) hypothesized that this change in sediment dynamics and corresponding changes in hydrodynamics have had dramatic effects on fish assemblages and the proliferation of alien fishes in the system. In addition, Nobriga et al. (2005) observed that submerged aquatic vegetation, especially the invasive Brazilian waterweed (*Egeria densa*), became increasingly abundant in the system during the past 20 years. This macrophyte increases water clarity by trapping suspended sediments and also has had measurable effects on the fish community. The increase in specific conductance during the study period is likely a function of decreasing river flow entering the estuary during the fall. There has been no significant long-term trend in runoff entering the watershed of the estuary during September–December (Dettinger and Cayan 1995). Thus, the positive specific conductance trend appears to be the result of water operations; the change could be a consequence of less water released from upstream dams into the system during this time of the year, or more water exported from the south delta, or a combination of both effects.

The third objective of our study was to determine if changes in water quality could explain the observed declines in the abundance of delta smelt, an annual fish species. The simple statistical models evaluated for delta smelt suggest that water quality may indeed be an important factor, at least during the past two decades, when food availability was severely reduced by the invasion of *Corbula*. This finding is consistent with previous analyses on population dynamics of delta smelt and striped bass, which revealed long-term declines in carrying capacity (Kimmerer et al. 2000; Bennett 2005). A decline in suitable physical habitat and decreases in prey availability are two of the likely mechanisms for the changes in carrying capacity. Studies on the physiological tolerances of delta smelt suggest that they can survive in salinities higher than those at which they have been found in the wild (Swanson et al. 2000). This suggests that recent patterns of fish recruitment and abundance are probably controlled by multiple interacting factors. Current efforts in parameratizing life cycle models for delta smelt and striped bass are likely to better quantify the relative importance of water quality on their population dynamics.

Although we believe that our results are robust given the substantial amount of data, we acknowledge that our analysis did not include all potential water quality, physical, or biological factors that affect fish occurrence and habitat. With respect to water quality, dissolved oxygen is perhaps the most important variable that we could not evaluate because of a lack of suitable data. Dissolved oxygen requirements for delta smelt are poorly understood; however, both striped bass and threadfin shad are sensitive to low levels of dissolved oxygen (Moyle 2002). In general, dissolved oxygen levels are not a major problem in most regions of the San Francisco Estuary. Problem areas include the extreme upstream limits of the south Delta during summer and fall (Lehman et al. 2004) and in the sloughs of Suisun Marsh during fall drainage of reclaimed marshlands (P. Moyle, University of California – Davis, Wildlife, Fish and Conservation Biology, Davis, California 95616, USA, personal communication). Both of these regions are outside of the sampling area covered by the FMWT.

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Physical habitat features such as substrate type (e.g., sand, mud, detritus, etc.), depth (e.g., shoals versus channels), and cover (e.g., woody debris or submerged aquatic vegetation) can also be important variables for fish habitat. Although data of this type are relatively scarce for fishes in San Francisco Estuary, we have no reason to believe that there have been major changes in these variables except for vegetative cover. As noted previously, there have been substantial increases in the amount of submerged aquatic vegetation during the past 20 years (Nobriga et al. 2005). We evaluated the increase in Secchi depth, one of the potential effects of this invasion, but were not able to analyze the effects of the increase in physical structure in the estuary.

Biotic variables, most notably competition, predation, and food availability, could have also played a major role in controlling the distribution of the three fishes (Hayes et al. 1996). Including competition in explanatory models would be extremely difficult in a practical sense because it is complicated to measure and is affected by many other variables. There have been some limited diet studies of piscivorous fishes in the estuary (e.g., Turner and Kelly 1966; Feyrer et al. 2003; Nobriga et al. 2006); however, the bioenergetics of predation within the estuary have remained largely unmeasured or modeled (but see Lindley and Mohr 2003 for a paper modeling striped bass predation on winter-run Chinook salmon (*Oncorhynchus tshawytscha*)).

Perhaps the greatest opportunity for improving our analyses of EQ distributions and trends lies with additional studies on the effects of food availability. Food availability has been successfully incorporated into similar GAMs (Maravelias 1999; Stoner et al. 2001). Moreover, some work in San Francisco Estuary suggests that prey availability can affect fish populations, especially striped bass (Kimmerer et al. 2000, 2001; Feyrer et al. 2003) and delta smelt (Bennett 2005). Although we did not include a direct measure of food availability in our models because there were no comparable invertebrate data at the spatial and temporal resolution of the FMWT data, our comparison of stock–recruit models for delta smelt suggests that food availability plays an important role.

We also acknowledge that our study is focused on conditions during a single season of the year, but it represents 1/3 of a year. Conditions during other seasons undoubtedly play a role in the population dynamics of the fish species we examined, but the changing physical habitat conditions during fall are likely important for several reasons. For age-0 striped bass, conditions during their first autumn play a role in the density-dependent survival exhibited by this species from age-0 to age-3 (Kimmerer et al. 2000). This is especially true given that food web changes have affected diet composition (Feyrer et al. 2003). Fall conditions may be even more important for delta smelt and threadfin shad, since these fish represent prespawning adults. In general, less suitable habitat constricts the range of these fishes, which combined with an altered food web, may affect their health and survival.

Overall, our study illustrates that ecological knowledge gained from long-term monitoring data can be a valuable tool to understand changes in aquatic ecosystems. First, they highlight the utility of long-term data sets to describe fish–EQ relationships, derive EQ, and track EQ trends for a variety of species. The long-term declining EQ trends and the apparent link to delta smelt abundance detected in this study corroborate previous hypotheses that the area of suitable physical and chemical habitat has played a role in the decline in fish abundance. However, the degree to which EQ could be used for management purposes remains unclear. Flow standards in San Francisco Estuary are based largely on a surrogate for salinity ($X_2$), particularly during winter and spring. While $X_2$ is a valuable generalized variable that is relatively easy to measure and is correlated with long-term abundance trends of multiple species (Jassby et al. 1995; Kimmerer 2002), the recent step change in the abundance of pelagic fishes suggests that salinity alone may not be sufficient to explain long-term trends in estuarine management. Our analyses of EQ showed that water transparency might also be an important consideration. For example, the combined effects of specific conductance and Secchi depth improved the stock–recruitment relationship for delta smelt, a species that has proven difficult to model using a variety of environmental data (Bennett 2005). Nonetheless, it is questionable whether there are simple ways to use variables such as Secchi depth for species management, at least during the fall period that we studied. Moreover, for the water quality data to be most effective for species management, additional information is needed to better define the mechanisms for the effects of water quality variables on aquatic organisms.

## Acknowledgements

This study was conducted under the auspices of the Interagency Ecological Program for the San Francisco Estuary (IEP). In particular, we thank C. Armor, R. Breuer, and R. Baxter, who facilitated IEP support. We also thank K. Souza for providing the FMWT data and support, M. Vayssieres for GIS help, E. Bass for assistance with data processing, and J. Pierce for drawing Fig. 1. Analyses by M. Guerin (Contra Costa Water District) provided the inspiration for separating the water quality data set into multiple time periods for evaluating stock–recruitment effects. Reviews by A. Mueller-Solger, S. Culberson, and two anonymous individuals improved the manuscript.

## References

Baskerville-Bridges, B., Lindberg, J.C., and Doroshov, S.I. 2004. The effect of light intensity, alga concentration, and prey density on the feeding behavior of delta smelt larvae. *In* Early life history of fishes in the San Francisco Estuary and Watershed. *Edited by* F. Feyrer, L. Brown, R. Brown, and J. Orsi. American Fisheries Society, Symposium 39, Bethesda, Md. pp. 219–228.

Bennett, W.A. 2005. Critical assessment of the delta smelt population in the San Francisco Estuary, California [online]. San Francisco Estuary and Watershed Science, Volume 3, Issue 2 (September 2005), Article 1. Available from http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art1 [accessed 1 June 2006].

Bennett, W.A., and Moyle, P.B. 1996. Where have all the fishes gone? Interactive factors producing fish declines in the Sacramento–San Joaquin Estuary. *In* San Francisco Bay: the ecosystem. *Edited by*

© 2007 NRC Canada

J.T. Hollibaugh. American Association for the Advancement of Science, San Francisco, Calif. pp. 519–542.

Bray, K.E. 1996. Habitat models as tools for evaluating historic change in the St. Mary's River. Can. J. Fish. Aquat. Sci. **53**: 88–98.

Bulger, A.J., Hayden, B.P., Monaco, M.E., Nelson, D.M., and McCormick-Ray, M.G. 1993. Biologically-based estuarine salinity zones derived from a multivariate analysis. Estuaries, **16**: 311–322:

Burnham, K.P., and Anderson, D.R. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York.

Cardinale, M., and Arrhenius, F. 2000. The influence of stock structure and environmental conditions on the recruitment process of Baltic cod estimated using a generalized additive model. Can. J. Fish. Aquat. Sci. **57**: 2402–2409.

Claramunt, R.M., and Wahl, D.H. 2000. The effects of abiotic and biotic factors in determining larval fish growth rates: a comparison across species and reservoirs. Trans. Am. Fish. Soc. **129**: 835–851.

Dege, M., and Brown, L.R. 2004. Effect of outflow on spring and summer distribution and abundance of larval and juvenile fishes in the upper San Francisco Estuary. *In* Early life history of fishes in the San Francisco Estuary and Watershed. *Edited by* F. Feyrer, L. Brown, R. Brown, and J. Orsi. American Fisheries Society, Symposium 39, Bethesda, Md. pp. 49–65.

Dettinger, M.D., and Cayan, D.R. 1995. Large-scale atmospheric forcing of recent trends toward early snowmelt in California. J. Clim. **8**: 606–623.

Feyrer, F., Herbold, B., Matern, S.A., and Moyle, P.B. 2003. Dietary shifts in a stressed fish assemblage: consequences of a bivalve invasion in the San Francisco Estuary. Environ. Biol. Fishes, **67**: 277–288.

Guisan, A., Edwards, T.C., and Hastie, T. 2002. Generalized linear and generalized additive models in studies of species distributions: setting the scene. Ecol. Model. **157**: 89–100.

Hayes, D.B., Ferreri, C.P., and Taylor, W.M. 1996. Linking fish habitat to their population dynamics. Can. J. Fish. Aquat. Sci. **53**(Suppl. 1): 383–390.

Hilborn, R., and Mangel, M. 1997. The ecological detective: confronting models with data. Princeton University Press, Princeton, N.J.

Houde, E.D., and Rutherford, E.S. 1993. Recent trends in estuarine fisheries: predictions and fish production and yield. Estuaries, **16**: 161–176.

Hurst, T.P., McKown, K.A., and Conover, D.O. 2004. Interannual and long-term variation in the nearshore fish community of the mesohaline Hudson River Estuary. Estuaries, **27**: 659–669.

Jackson, D.A., Peres-Neto, P.R., and Olden, J.D. 2001. What controls who is where in freshwater fish communities — the roles of biotic, abiotic, and spatial factors. Can. J. Fish. Aquat. Sci. **58**: 157–170.

Jassby, A.D., Kimmerer, W.J., Monismith, S.G., Armor, C., Cloern, J.E., Powell, T.M., Schubel, J.R., and Vendlinski, T.J. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecol. Appl. **5**: 272–289.

Jassby, A.D., Cloern, J.D., and Cole, B.E. 2002. Annual primary production: patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnol. Oceanogr. **47**: 698–712.

Kimmerer, W.J. 2002. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Mar. Ecol. Prog. Ser. **243**: 39–55.

Kimmerer, W.J., and Orsi, J.J. 1996. Changes in the zooplankton of the San Francisco Bay Estuary since the introduction of the clam *Potamocorbula amurensis*. *In* San Francisco Bay: the ecosystem. *Edited by* J.T. Hollibaugh. Pacific Division, American Association for the Advancement of Science, San Francisco, Calif. pp. 403–424.

Kimmerer, W.J., Cowan, J.H., Miller, L.W., and Rose, K.A. 2000. Analysis of an estuarine striped bass (*Morone saxatilis*) population: influence of density-dependent mortality between metamorphosis and recruitment. Can. J. Fish. Aquat. Sci. **57**: 478–486.

Kimmerer, W.J., Cowan, J.H., Miller, L.W., and Rose, K.A. 2001. Analysis of an estuarine striped bass population: effects of environmental conditions during early life. Estuaries, **24**: 557–575.

Lehman, P.W., Sevier, J., Giulianotti, J., and Johnson, M. 2004. Sources of oxygen demand in the lower San Joaquin River, California. Estuaries, **27**: 405–418.

Levin, P.S., and Stunz, G.W. 2005. Habitat triage for exploited fishes: Can we identify essential "Essential Fish Habitat?" Estuar. Coast. Shelf Sci. **64**: 70–78.

Lindley, S.T., and Mohr, M.S. 2003. Modeling the effect of striped bass (*Morone saxatilis*) on the population viability of Sacramento River winter-run chinook salmon (*Oncorhynchus tshawytscha*). Fish. Bull. **101**: 321–331.

Maravelias, C. 1999. Habitat selection and clustering of a pelagic fish: effects of topography and bathymetry on species dynamics. Can. J. Fish. Aquat. Sci. **56**: 437–450.

Matern, S.A., Moyle, P.B., and Pierce, L.C. 2002. Native and alien fishes in a California estuarine marsh: twenty-one years of changing assemblages. Trans. Am. Fish. Soc. **131**: 797–816.

Moyle, P.B. 2002. Inland fishes of California. Revised and expanded. University of California Press, Berkeley, Calif.

Moyle, P.B., Herbold, B., Stevens, D.E., and Miller, L.W. 1992. Life history and status of delta smelt in the Sacramento–San Joaquin Estuary, California. Trans. Am. Fish. Soc. **121**: 67–77.

Nichols, F.H., Cloern, J.E., Luoma, S.N., and Peterson, D.H. 1986. The modification of an estuary. Science (Washington), **231**: 567–573.

Nobriga, M.L., Feyrer, F., Baxter, R.D., and Chotkowski, M. 2005. Fish community ecology in an altered river delta: species composition, life history strategies and biomass. Estuaries, **28**: 776–785.

Nobriga, M., Feyrer, F., and Baxter, R. 2006. Aspects of Sacramento pikeminnow biology in nearshore habitats of the Sacramento–San Joaquin Delta. West. N. Am. Nat. **66**: 106–114.

Norcross, B.L., Muter, F.J., and Holladay, B.A. 1997. Habitat models for juvenile pleuronectids around Kodiak Island, Alaska. Fish. Bull. **95**: 504–520.

Rose, K.A. 2000. Why are quantitative relationships between environmental quality and fish populations so elusive? Ecol. Appl. **10**: 367–385.

Stevens, D.E., and Miller, L.W. 1983. Effects of river flow on abundance of young chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento–San Joaquin River system. Trans. Am. Fish. Soc. **3**: 425–437.

Stevens, D.E., Kohlhorst, D.W., Miller, L.W., and Kelley, D.W. 1985. The decline of striped bass in the Sacramento–San Joaquin estuary, California. Trans. Am. Fish. Soc. **114**: 12–30.

Stoner, A.W., Manderson, J.P., and Pessutti, J.P. 2001. Spatially explicit analysis of estuarine habitat for juvenile winter flounder: combining generalized additive models and geographic information systems. Mar. Ecol. Prog. Ser. **213**: 253–271.

Swanson, C., Reid, T., Young, P.S., and Cech, J.J. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered estuary. Oecologia, **123**: 384–390.

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Turner, J.L., and Chadwick, H.K. 1972. Distribution and abundance of young-of-the-year striped bass, *Morone saxatilis*, in relation to river flow in the Sacramento–San Joaquin Estuary. Trans. Am. Fish. Soc. **101**: 442–45.

Turner, J.L., and Kelley, D.W. (*Editors*). 1966. Ecological studies of the Sacramento–San Joaquin Delta. Part II. Fishes of the Delta. Calif. Dep. Fish Game Fish Bull. 136.

Venables, W.N., and Ripley, B.D. 1997. Modern applied statistics with S-plus. 2nd ed. Springer, New York.

Wright, S.A., and Schoellhamer, D.H. 2004. Trends in sediment yield of the Sacramento River, California, 1957–2001 [online]. San Francisco Estuary and Watershed Science, Volume 2, Issue 2 (May 2004), Article 2. Available from http://repositories.cdlib.org/jmie/sfews/vol2/iss2/art2/ [accessed 1 June 2006].

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JULY 2007

SAN FRANCISCO ESTUARY & WATERSHED SCIENCE

Published by the California Bay-Delta Authority Science Program and the John Muir Institute of the Environment

# Effects of Flow Diversions on Water and Habitat Quality: Examples from California's Highly Manipulated Sacramento-San Joaquin Delta

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## ABSTRACT

We use selected monitoring data to illustrate how localized water diversions from seasonal barriers, gate operations, and export pumps alter water quality across the Sacramento-San Joaquin Delta (California). Dynamics of water-quality variability are complex because the Delta is a mixing zone of water from the Sacramento and San Joaquin Rivers, agricultural return water, and the San Francisco Estuary. Each source has distinct water-quality characteristics, and the contribution of each source varies in response to natural hydrologic variability and water diversions. We use simulations with a tidal hydrodynamic model to reveal how three diversion events, as case studies, influence water quality through their alteration of Delta-wide water circulation patterns and flushing time. Reduction of export pumping decreases the proportion of Sacramento- to San Joaquin-derived fresh water in the central Delta, leading to rapid increases in salinity. Delta Cross Channel gate operations control salinity in the western Delta and alter the freshwater source distribution in the central Delta. Removal of the head of Old River barrier, in autumn, increases the flushing time of the Stockton Ship Channel from days to weeks, contributing to a depletion of dissolved oxygen. Each shift in water quality has implications either for habitat quality or municipal drinking water, illustrating the importance of a systems view to anticipate the suite of changes induced by flow manipulations, and to minimize the conflicts inherent in allocations of scarce resources to meet multiple objectives.

## KEYWORDS

Sacramento-San Joaquin Delta, diversion, water management, numerical modeling, water quality

## SUGGESTED CITATION

Monsen, Nancy E., James E. Cloern, and Jon R. Burau. Effects of Flow Diversions on Water and Habitat Quality: Examples from California's Highly Manipulated Sacramento-San Joaquin Delta. San Francisco Estuary and Watershed Science. Vol. 5, Issue 3 [July 2007]. Article 2.

http://repositories.cdlib.org/jmie/sfews/vol5/iss3/art2

## INTRODUCTION

Water flow through California's Sacramento-San Joaquin Delta (Delta) is manipulated to satisfy multiple objectives, including: exports to meet distant agricul-

tural and municipal demands and routing of flows with barriers or gates to facilitate migration of salmon, enhance flushing to prevent anoxia, or repel salt intrusion that degrades drinking water quality. Each hydraulic manipulation is implemented to satisfy a specific, often geographically localized objective. However, localized diversions can have regional-scale consequences, some unintended and conflicting with other management objectives.

Hydrodynamic models can be applied to identify and measure the processes through which localized diversions influence regional-scale flow paths and water quality, building toward a broad ecosystems perspective of the exceedingly complex and highly manipulated Delta. While a systems perspective is inherent in single-objective water operations, it has not been developed to guide the broader challenge of optimizing allocation of California's water supply to satisfy agricultural and municipal demands and sustain effective strategies of ecosystem restoration. Increasingly challenging conflicts of water allocation motivate the search for a consensus vision of the Delta's future (Lund et al. 2006), and the visioning process requires quantitative approaches for assessing the ecosystem-scale consequences of multiple hydraulic manipulations. Here we illustrate how diversions through gate, barrier, and pump operations can rapidly change water quality conditions within the Delta. These changes have important implications for habitat quality and sustainability of the Delta's native biota.

The spatial patterns and temporal variability of water-quality indicators in the Delta are complex and driven by natural processes, such as seasonal river flow or tidal oscillations of salinity gradients (e.g. Figure 1A,B) or oscillations of dissolved oxygen over the diel light cycle (Figure 1C). Water-quality indicators also shift, sometimes rapidly, in response to water diversions. Here we use a tidal hydrodynamic model to explore cause-effect relationships between flow manipulations and shifts in water quality using three diversion events as case studies: salinity increase in the central Delta when pumped exports were curtailed (Figure 1A); salinity increase in the lower San Joaquin River when gates were closed at the Delta Cross Channel (Figure 1B); and oxygen depletion in the Stockton Ship Channel when a temporary barrier across Old River was removed

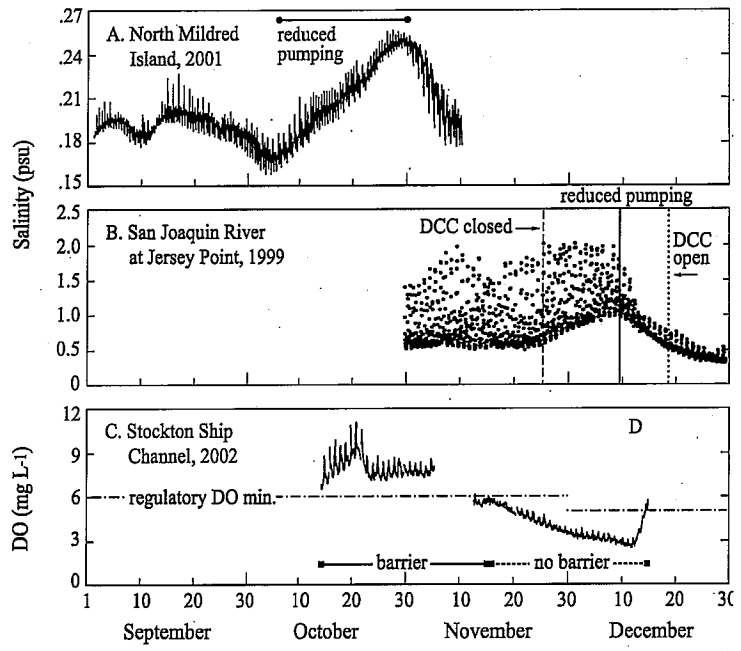



**Figure 1.** Water quality time series data used in three case studies. (A) Salinity measured 1 m above the channel bottom at the northern opening of Mildred Island. (B) Salinity measured at Jersey Point (San Joaquin River). (C) Dissolved oxygen concentration 1 m below the surface in the Stockton Ship Channel at Rough and Ready Island.

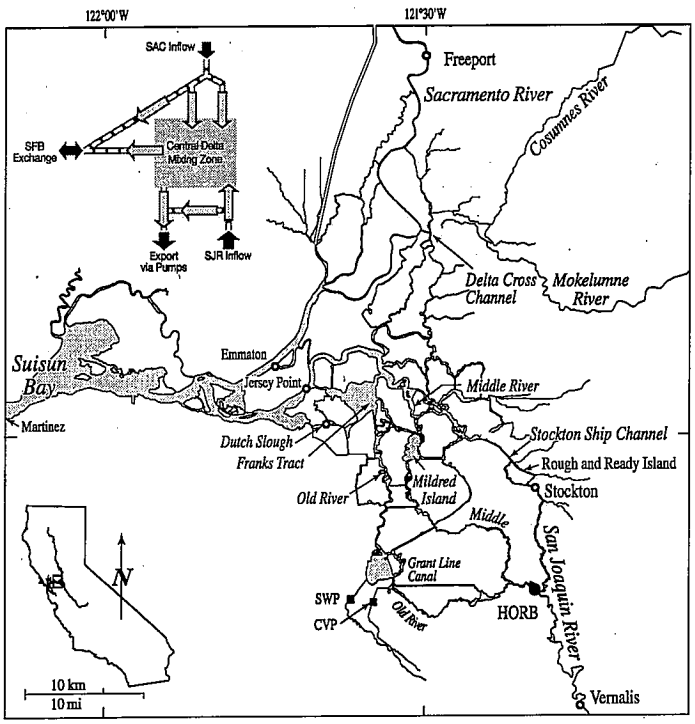
(Figure 1C). Model simulations explain how each diversion alters the flow path, source mixture, and flushing rate of water within the Delta, providing mechanistic and spatially-explicit representations of how diversions influence water quality.

The effects of individual water operations on water quality have been learned empirically over time, but the underlying mechanisms of those effects, their interactions, and their spatial complexity have not been clearly established. Our goal here is to illustrate the value of simulations with hydrodynamic models to understand how diversions modify the routing and rates of water flow through the Delta, and how these modifications influence water quality through their alteration of source mixtures and flushing rates. We view this as a step toward a comprehensive understanding of how diversions interact with other processes to influence habitat quality and sustainability of diverse native biota, including species on the brink of extinction in the Delta ecosystem.

## BACKGROUND AND STUDY DESIGN

The Delta is the convergence zone of two large rivers (Figure 2), the Sacramento and San Joaquin, draining a 153,000 km$^2$ watershed that captures runoff from winter-spring rainfall in the Central Valley and spring snowmelt in the Sierra Nevada mountains. The Delta, formerly a 1,400-km$^2$ wetland (Atwater and others 1979), has been transformed into a patchwork of agricultural tracts surrounded by leveed channels, tidal lakes and remnant patches of marsh. As the transition zone between a large river-watershed and San Francisco Bay, the Delta is a migration route for anadromous fish such as salmon, sturgeon, and shad, and permanent habitat for native species such as Delta smelt and Sacramento splittail.

The Delta is the hub of a water-development infrastructure that captures runoff during the wet season and transfers an average of 7.1 km$^3$/year (1995 level of development) from the north to the south and coast during the dry summer-autumn (CDWR 1998). The Sacramento contributes the largest volume of freshwater inflow to the Delta, with daily median flows ranging seasonally from 320 to 1230 m$^3$ s$^{-1}$. The San Joaquin, which has several significant diversions upstream of the Delta, is a smaller river by volume with daily median flow between 36 and 150 m$^3$ s$^{-1}$ (www.iep.water.ca.gov/dayflow/, median based on data from water years 1956-2001). In contrast, tidal flow at the Delta's western boundary is typically in the range of ±8500 m$^3$ s$^{-1}$.




re 2. Map of the Sacramento-San Joaquin Delta. Inset: ematic illustrating the base flow routes through the Delta.

Upstream reservoir releases are routed across the Delta to provide drinking water for 22 million people in coastal cities, and supply water to over 18,000 km$^2$ of irrigated farmland producing crops valued over $13 billion annually (CDFA 2002). These interbasin transfers are pumped from the south Delta (Figure 2) by the State Water Project (SWP) and the Central Valley Project (CVP). The daily median export from the SWP and CVP ranges between 63 and 292 m$^3$ s$^{-1}$ (www.iep.water.ca.gov/dayflow/, median based on data from water years 1956-2001). Over 2,200 diversions from Delta channels also supply water for municipalities and irrigation of local farmland (Herren and Kawasaki 2001).

The challenge of satisfying multiple demands on the Delta's water resource is complex because this critical habitat for native species is a mixing zone of estuarine brackish water and three primary sources of fresh water, each having distinct water chemistry (Table 1). The San Joaquin River contains a large fraction of irrigation drainage and has high concentrations of dissolved salts, nutrients, organic carbon, and toxic contaminants such as selenium (Table 1). The Sacramento River is less impacted by upstream agricultural inputs and has low concentrations of these constituents. Agricultural drainage from peat-rich Delta soils is highly enriched in dissolved organic carbon. In addition to these freshwater sources, tides transport brackish estuarine water into the Delta during periods of low river inflow, degrading drinking water quality and agricultural supplies.

Inflows to the Delta are manipulated by an array of diversions, and we illustrate examples from operations of three diversion types: (1) exports from the South Delta through pumping by the SWP and CVP; (2) gates that divert flows from the Sacramento River into the

**Table 1.** Water quality comparison between the Sacramento River, San Joaquin River, and In-Delta Agricultural Return water for water years 1999-2001.

| Water Quality Parameter | Sacramento at Freeport [1] | San Joaquin at Vernalis | In-Delta Agricultural Return Water [2] |
|---|---|---|---|
| Specific Conductance (mmhos $cm^{-1}$) | 144 ± 28 | 621 ± 183 | 562 ± 206 |
| pH | 7.8 ± 0.2 | 8.0 ± 0.4 | 6.8 ± 0.4 |
| Alkalinity (mg $CaCO_3$ $L^{-1}$) | 55 ± 12 | 85 ± 24 | 83 ± 18 |
| Dissolved Oxygen (mg $L^{-1}$) | 9.8 ± 1.4 | 9.6 ± 1.4 | 5.5 ± 2.1 |
| Nitrite+Nitrate (mg N $L^{-1}$) | 0.12 ± 0.05 | 1.62 ± 0.59 | |
| Orthophosphate (mg P $L^{-1}$) | 0.024 ± 0.007 | 0.107 ± 0.054 | |
| Dissolved Organic Carbon (mg C $L^{-1}$) | 1.84 ± 0.53 | 2.83 ± 0.47 | 14.1 ± 7.7 |
| Total Dissolved Selenium[3] (nmol $L^{-1}$) | 0.91 ± 0.27 | 8.6 ± 2.5 | Negligible[4] |

[1] USGS Water Quality Database (WY1999-WY2001) for Sacramento (USGS 11447650) and San Joaquin (USGS 11303500) rivers unless otherwise noted.

[2] California Department of Water Resources Municipal Water Quality Investigations Program (WY1999-WY2001) for Bacon Island Pumping Plant (DWR B9V75881342), and Twitchell Island Pumping Plant 1 (DWR B9V80661391) (CDWR 2003); DOC data only from Bacon Island. Different crops produce varying levels of DOC, agricultural return water DOC is expected to vary significantly throughout the Delta.

[3] Sacramento river average from two studies (1984-2000). San Joaquin average from 1997-2000 sampling period. (Cutter and Cutter 2004)

[4] Personal communication AR Stewart, 14 May 2003

central Delta via the Delta Cross Channel; and (3) a barrier placed at the head of Old River to maintain flows in the San Joaquin River (see Figure 2). We use selected time series data to illustrate the coherent responses of water-quality indicators to operations of these diversions, and then use a hydrodynamic model to identify the transport mechanisms of those responses. We use salinity as an example of an indicator that is influenced by changing source mixtures of water within the Delta, and dissolved oxygen (DO) as an example of an indicator influenced by both transport processes and biogeochemical reactions.

## METHODS

### Data Sources

The primary data source was the archive of federal and state monitoring data maintained by the Interagency Ecological Program (IEP, www.iep.water.ca.gov). Electrical conductivity is measured at Emmaton, Jersey Point, and Dutch Slough (Figure 2) by the U.S. Bureau of Reclamation. Salinity at these locations was computed from electrical conductivity using water temperature measured by the California Department of Water Resources (CDWR) at Rio Vista (Sacramento River) and Antioch (San Joaquin River). We used these salinity records as an indicator of water-quality responses to operations of the Delta Cross Channel gates during autumn 1999. The CDWR measures near-surface DO continuously within the Stockton ship channel, and the U.S. Geological Survey (USGS) measures San Joaquin flow both at Vernalis, upstream of Old River, and at Stockton directly upstream of the Stockton ship

channel (Figure 2). We used flow and DO measurements during autumn 2002 to illustrate effects of a barrier diversion.

We also used results from a study to measure transports and water quality dynamics in Mildred Island, located in the central Delta (Figure 2). Moored instruments measured electrical conductivity, temperature, and velocities through the major entrances to Mildred Island and surrounding channels every 10 minutes from 22 August through 14 November 2001 (for detailed methods see Lucas et al. 2006). Velocity was converted into flow (Simpson and Oltmann 1993), and salinity was computed from temperature and electrical conductivity measured with Seabird sensors. We used flow and salinity measurements around Mildred Island to illustrate shifts in freshwater source resulting from changes in export pump operations.

## Numerical Modeling

We used the multi-dimensional hydrodynamic model Delta TRIM3D to identify the transport processes of water quality variability induced by each diversion. Gross et al. (1999) incorporated scalar transport routines into the TRIM3D hydrodynamic computation core developed by Casulli and Cattani (1994). Monsen (2001) created a Delta specific version of the model (Delta TRIM) that incorporated Delta bathymetry and hydraulic structure operations. Delta TRIM has been calibrated and compared to measured stage, flow, and salinity under a variety of flow boundary conditions and hydraulic operations (Monsen 2001). The model was run in two-dimensional mode to calculate depth-averaged stage, velocity, and scalar concentrations at 150,000 points on a 50-m grid with a 40 second time step. All model simulations were ramped up for at least a 24 h simulation period before the introduction of scalars or discrete particles.

Delta TRIM was run for the periods August-December 2001 and August-December 2002, using a tidal boundary condition as measured stage at Martinez and flow boundary conditions as discharge of the Sacramento River at Freeport and San Joaquin River at Vernalis (Figure 2). All pump and gate operations, within-Delta diversions and placement/removal of barriers were represented in the model. Model simulations were used to compute source mixtures of water from concentrations of conservative scalars introduced at the model boundaries as tracers, and flushing times from the displacement of discrete particles.

## Water Source Composition

Water at any location was assumed to be a mixture of three sources: Sacramento, San Joaquin, and "other" water. The "other" category included bay, agricultural return, and "old" water (having a residence time greater than the simulation period). The total scalar mass ($M_{TOT}$) in a water column is the sum of scalar masses from each source:

(1) $$M_{TOT} = M_{SAC} + M_{SJR} + M_{OTHER}$$

Re-writing equation (1) in terms of source concentrations ($C_{SAC}$, $C_{SJR}$, $C_{OTHER}$) and water column volume ($V_{TOT}$):

(2) $$C_{TOT}V_{TOT} = C_{SAC}V_{TOT} + C_{SJR}V_{TOT} + C_{OTHER}V_{TOT}$$

where $C_{TOT}$ is the scalar concentration from all sources. We divided equation (2) by $C_{TOT}V_{TOT}$ to calculate the mass fraction from each freshwater source at any location (equation (3)).

(3) $$1 = \frac{C_{SAC}}{C_{TOT}} + \frac{C_{SJR}}{C_{TOT}} + \frac{C_{OTHER}}{C_{TOT}}$$

Because the numerical model conserves mass (Gross et al. 1999), we traced Sacramento and San Joaquin source waters as two different scalars. The total scalar concentration, $C_{TOT}$, was fixed at a constant value at each river boundary. Boundary conditions for the Sacramento source scalar were $C_{SAC} = C_{TOT}$ at the Sacramento boundary (Freeport) and $C_{SAC} = 0$ at all other boundaries. Similarly for the San Joaquin source scalar, the boundary conditions were $C_{SJR} = C_{TOT}$ at the San Joaquin boundary (Vernalis) and $C_{SJR} = 0$ at all other boundaries. In the domain interior, both the Sacramento and San Joaquin tracer concentrations were initialized to zero at all grid cells at the beginning of the simulation.

During the simulation, scalar concentrations at all grid cells in the region of interest (e.g. Mildred Island) were

recorded hourly. Although inflows, exports and gate operations changed constantly, tracer concentrations approached quasi-steady state distributions. Based on equation (3), the fraction of water originating from any source (i.e. Sacramento or San Joaquin) in a grid cell was the scalar concentration divided by the total concentration ($C_{TOT}$).

### Flushing Time

Flushing time is an integrative parameter that describes the general exchange characteristics of a water body. We used Delta TRIM to compute an e-folding flushing time in which a number ($P_0$) of neutrally buoyant particles was introduced into the model domain of interest (Monsen et al. 2002). Trajectories of each particle were calculated each time step based on the model velocity field (e.g. see Lucas et al. 2002, Figures 3-5), using the method of Cheng et al. (1993). The e-folding flushing time ($T_f$) was calculated from a linear regression of the time series of the number of particles, P(t), remaining in the domain of interest every hour using the equation:

$$(4) \quad \ln P(t) = -\left(\frac{1}{T_f}\right)t + \ln P_0$$

## RESULTS AND DISCUSSION

The effects of each diversion are generalized in schematics showing water sources and transport paths linked to the central Delta (Figure 3). Fresh water is delivered as inflows from the Sacramento and San Joaquin Rivers, exported as pumped diversions by the SWP and CVP, and mixed with estuarine waters by tidal exchange with the San Francisco Estuary. The central Delta network of channels and open water regions is a dynamic mixing zone where the source mixture of water changes with fluctuating river discharge, tides, and export rates (Figure 3A). The source mixture is not uniform throughout this mixing zone. For example, the mixture on Middle River (Figure 2) can be different from Old River at any time. Flow paths are modified by closure of DCC gates that route fresh water into the Sacramento River (Figure 3B), and by seasonal construction of the head of Old River barrier to divert flows into the San Joaquin River (Figure 3C).

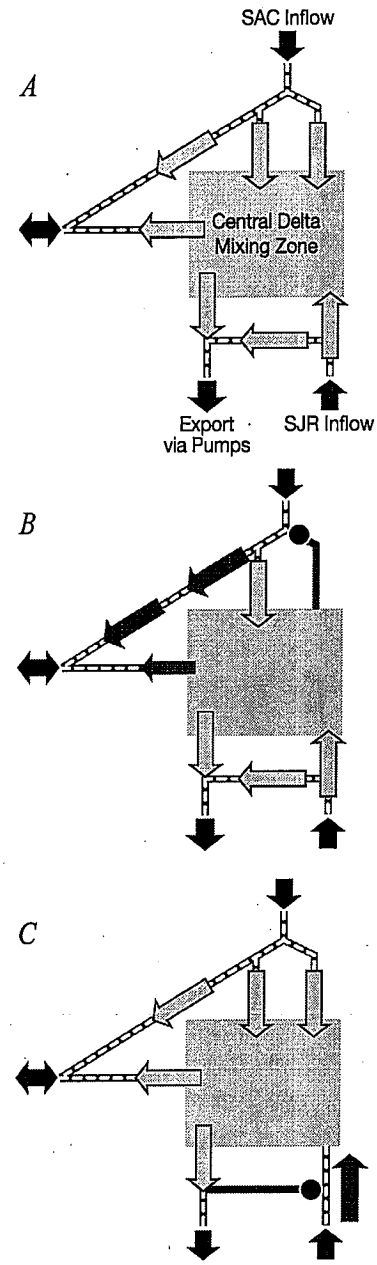



**Figure 3.** Schematics illustrating how diversions alter flow routing through the Delta. Dark blue arrows represent fresh water inputs to and exports from the Delta. The bi-directional arrow represents tidal exchange of Delta water with San Francisco Bay. Red denotes flow alterations caused by each diversion. (A) Base flow routes repeated from Figure 1, inset. (B) Closing gates at the Delta Cross Channel redirects flow to the Sacramento River toward San Francisco Bay and away from the central Delta. (C) The head of Old River barrier directs San Joaquin flow to the central Delta mixing zone rather than to the south Delta toward the export pumps.

## Export Diversions Alter Regional Flows and Salinity Distributions

The SWP reduced its exports between 7 October and 31 October 2001 (Figure 4A). This pumping curtailment allowed more fresh water to exit the Delta through its western boundary (Figure 3A), which, as intended, lowered salinity in the western Delta. However, the salinity response in the central Delta (Mildred Island) was opposite and unexpected: bottom salinity increased steadily at the northern opening of Mildred Island (Figure 4B) and at all other sampled locations in/around Mildred Island between 7-31 October 2001. Flow measurements and model simulations indicate that this salinity increase was caused by a shift in dominant freshwater source from the low-conductivity Sacramento (Table 1) to the high-conductivity San Joaquin.

The SWP and CVP pumps draw water from both the south Delta and the central mixing zone (Figure 3A). The draw of the pumps is large enough to redirect the net flow in nearby channels toward the export facili- altering regional circulation patterns. Mildred Island is bounded by two north-south channels (Middle River and Latham Slough) and two east-west channels. It is separated from these deeper channels by (leaky) levees with discrete openings at the north and south. Flow measurements revealed an altered circulation pattern throughout the Mildred Island region as a result of altered pump operations. During the September period of high SWP export, the mean net (tidal residual) north-to-south flow via Middle River just north of Mildred Island was 100 $m^3 s^{-1}$. In October when exports were curtailed, the mean flow fell to 56 $m^3 s^{-1}$. Because less water was drawn toward the pumps, the net southerly residual flow was reduced in the Mildred Island region. In some locations, the direction of net flow reversed.

The shift in net north-to-south flow around Mildred Island was primarily due to changes in pump operations rather than significant changes in Delta hydrology. During September and early October 2001, the tidally averaged Sacramento inflow (at Freeport, Figure 2) ranged from 350-380 $m^3 s^{-1}$ and the San quin inflow (at Vernalis) ranged from 35-45 $m^3 s^{-1}$. During the period of pump reduction, the tidally averaged Sacramento inflow (at Freeport) ranged from 200-300 $m^3 s^{-1}$ and the San Joaquin inflow (at Vernalis) had a pulse inflow that peaked at 82 $m^3 s^{-1}$ on 28 October.

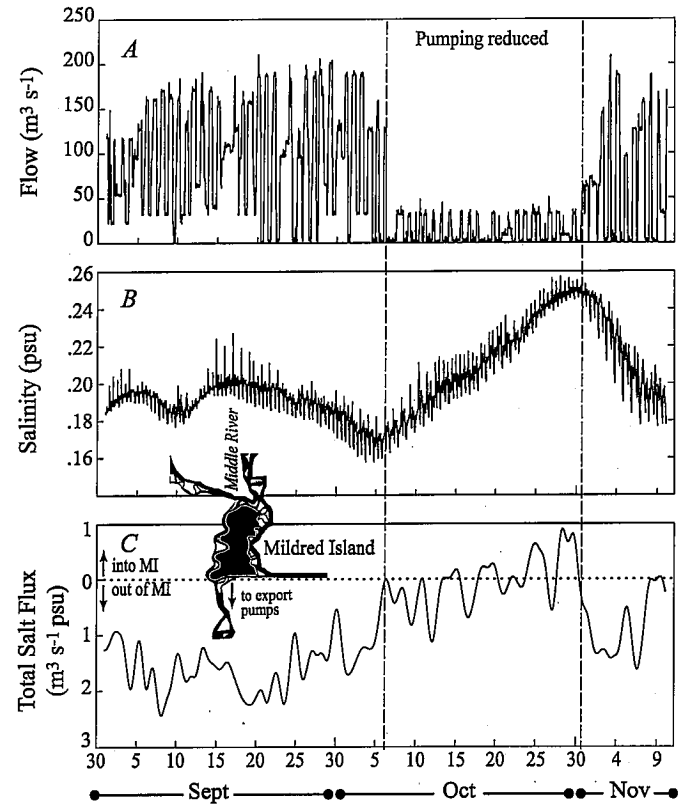



**Figure 4.** State Water Project exports alter salinity in Mildred Island (central Delta) in autumn 2001. (A) SWP export rate from 1 September–14 November 2001. (B) Salinity 1 m above the channel bottom at the northern opening of Mildred Island. (C) Advective salt flux at the southern opening of Mildred Island. Inset: map of Mildred Island and the surrounding channels. Data sources: State Water Project pump operation data: IEP database station CHSWP003. Salinity and flow data (22 Aug 2001–14 Nov 2001) from Lucas et al. (2006).

Simulations with Delta TRIM show how this modification of circulation altered water composition as a shift in dominance from Sacramento to San Joaquin water. Sacramento water can be transported toward the export pumps through either Old or Middle River (Figure 2). When export pumps operate at high capacity, Old and Middle Rivers become a freshwater corridor of

Sacramento-derived water. On 6 October 2001, immediately prior to pumping reduction, the Mildred Island region was dominated by Sacramento-derived water (Figure 5a). However, San Joaquin source water dominated the region on 6 November, after a month of pump curtailment when the Sacramento freshwater corridor was constricted to Old River (Figure 5b). The San Joaquin source of water increased inside Mildred Island (Figure 5d) because the regional mass balance changed: less Sacramento-derived water entered from the north and more San Joaquin derived water exchanged with Mildred Island from the channel at its southeast corner.

Pumping curtailment also altered the exchange rate between Mildred Island and its surrounding channels. Total salt flux (<qc>) was computed for the south opening of Mildred Island as the tidally filtered product of flow (q) and salinity (c) (Fischer et al. 1979). During peak SWP exports in late September, the salt flux was directed out of Mildred Island toward the export pumps (Figure 4C). After pumping was curtailed, the salt flux was significantly reduced and, during some short periods, it reversed as salt entered Mildred Island from the channels adjacent to its southeast corner.

The coherent changes in flow and salinity around Mildred Island with pump operations illustrate how exports generate regional responses. Salinity in the central Delta changed almost instantaneously with changes in export diversions occurring 25 km away. Simulations with a hydrodynamic model reveal how pump curtailment altered local exchanges and regional flows such that low-conductivity Sacramento water was gradually replaced with high-conductivity San Joaquin water. However, this shift in source mixture was not spatially uniform (Figure 5) because the routing of Sacramento-derived water was modified differentially within Old River and Middle River. Hydrodynamic models provide a tool for discovering and understanding the spatial complexity of water quality dynamics and their responses to diversions.

## Delta Cross Channel Diversions Alter Source Water Distributions

The Delta Cross Channel (DCC), a 1,100 m long, 8 m deep trapezoidal channel in the north Delta (Figure 2),

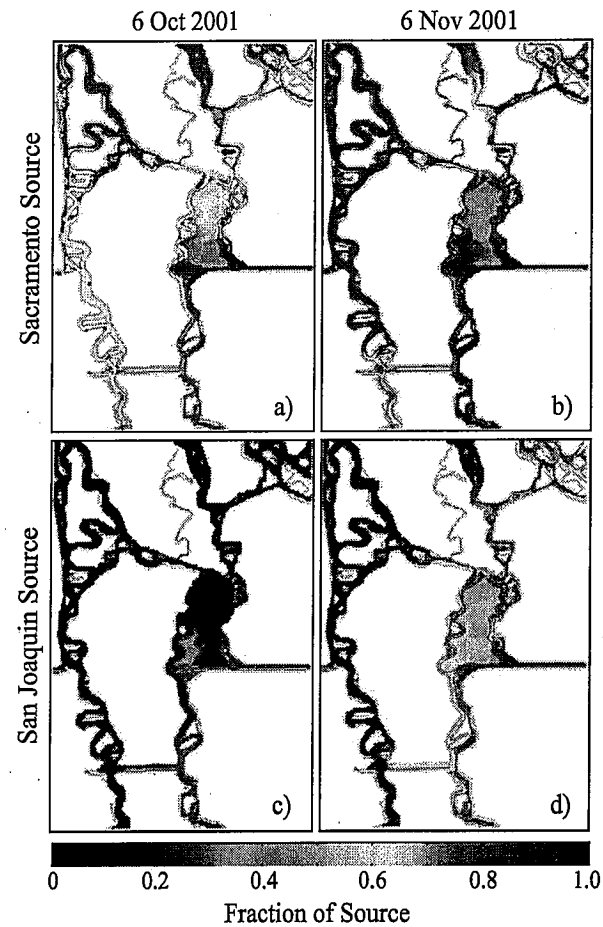



**Figure 5.** Model-computed fractions of Sacramento (a, b) and San Joaquin River (c, d) source water at each grid cell around Mildred Island on 6 October 2001 (a, c), immediately prior to reduced pump operations, and on 6 November 2001 (b, d) after a month of pump curtailment.

diverts high-quality Sacramento River water into the central Delta. Flows are controlled by gates that are normally kept open to maintain cross-Delta flows. The DCC gates are closed in late summer and autumn, when inflows are low and estuarine salinity intrusion peaks, to facilitate salmon emigration. During an extreme salinity intrusion event in November 1999, low river flow and high pump exports co-occurred and created a conflict between DCC operations to (a) repel salt intrusion to meet salinity standards (gates open, Figure 3A) and (b) route flows and juvenile salmon down the Sacramento River (gates closed, Figure 3B). Salinity across the western Delta changed rapidly in response to DCC operations during this period (Figure 6A-C).

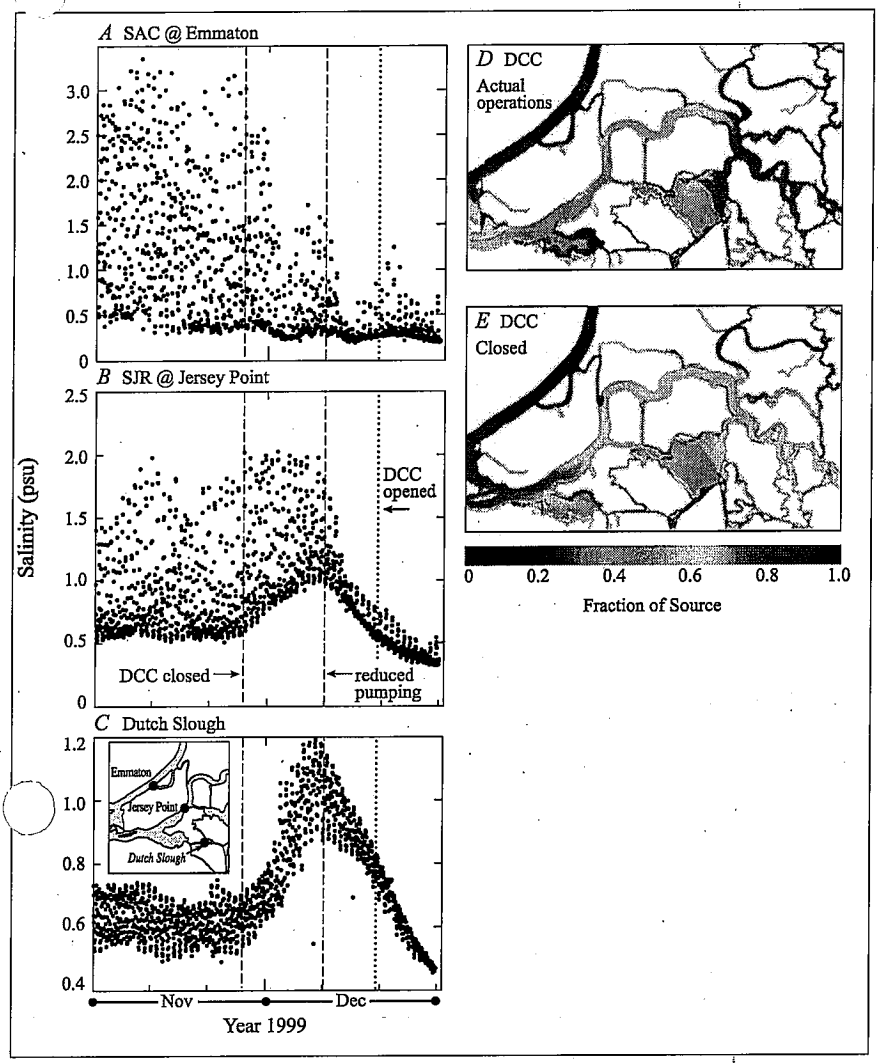



**Figure 6.** Influence of Delta Cross Channel gate operations on salinity intrusion during November-December 1999 at (A) Emmaton, (B) Jersey Point, and (C) Dutch Slough (inset: map of the region). Data source: IEP Database: electrical conductivity (Station: RSAC092, RSAN018, SLDUT007), water temperature (Station: RSAC101, RSAN007), Delta Cross Channel gate operations (Station: RSAC128), and export pump operations (Station: CHSWP003, CHDMC004). (D) Color maps show the distribution of modeled Sacramento source water on 13 September 2001, comparing simulations with (D) actual operation of the Delta Cross Channel and (E) Delta Cross Channel gates closed for the entire simulation.

The DCC gates were closed on 26 November as the salmon migration began. This closure altered the circulation pattern in the north Delta by directing more Sacramento water down the main stem of the Sacramento away from the central Delta (see Figure 3B). As a result, less fresh water was available in the central Delta to prevent salinity intrusion on the San Joaquin stem of the western Delta. Salinity decreased at Emmaton on the Sacramento River, but tidally-averaged salinity increased almost immediately on the San Joaquin at Jersey Point and Dutch Slough (Figure 6A-C). Salt intrusion into the San Joaquin progressed until export pumping was curtailed on 10 December in an effort to prevent chloride concentrations from exceeding the 250 mg $L^{-1}$ chloride standard at Rock Slough (CDWR 2001). Export pump curtailment resulted in more San Joaquin-derived fresh water entering the western Delta, repelling intrusive sea water and reducing salinities at both Jersey Point and Dutch Slough. Despite reduced export pumping, the chloride level continued to rise at Rock Slough eventually averaging 258 mg $L^{-1}$ on 20 December. Although the salmon emigration was still in progress, DCC gates were re-opened on 15 December to repel salt intrusion on the San Joaquin stem of the western Delta, further lowering salinity at Jersey Point and Dutch Slough (Figure 6B,C).

To investigate how regional circulation patterns are altered by DCC gate diversions, we compared two modeling simulations using autumn 2001 hydrologic conditions to represent typical autumn inflows and exports. Delta hydrodynamics were simulated for 9 August-13 September 2001, under scenarios of: (a) actual DCC operations in which the gates were open except for short (4-6 h) closures during 2 weeks in August; and (b) closure of DCC gates for the entire period. We then mapped the fractions of Sacramento River water after 35 days of simulation, when the model attained a quasi-steady state.

When the gates were open, the eastern central Delta, including northeast Franks Tract, was dominated by Sacramento water (Figure 6D). In contrast, when the DCC gates were closed, less Sacramento water reached the eastern side of the central Delta because less Sacramento water was transferred to this region via

Mokulemne channels (Figure 6E). Since the Sacramento and San Joaquin rivers have different electrical conductivity (Table 1), changes in DCC operations altered salinity across the central Delta including the large shallow habitat of Franks Tract.

This second example illustrates how a localized diversion in the north Delta can influence regional-scale water quality through its modification of the flow paths of Sacramento- and San Joaquin-derived river water. The spatial complexity of this response is evident in monitoring records showing concurrent salinity decreases in the lower Sacramento River and salinity increases in the lower San Joaquin River (Figures 6A-C). Simulations of scalar transport provide a clear visualization of the hydraulic response to DCC gate closure. These visualizations reveal the fine-resolution spatial complexity underlying the differential salinity responses measured at a few fixed locations (Figure 6D,E). The Delta is subjected to multiple diversions and this example highlights the compounding effect of gate and export operations on salinity distributions (Figures 6A-C).

## Old River Barrier Diversions Alter Flushing and Dissolved Oxygen

The San Joaquin River splits into two channels as it enters the Delta: Old River carries flows west toward the export pumps, and the San Joaquin River carries flows north toward the central mixing zone (Figure 3A). The head of Old River barrier (HORB), a temporary rock wall (~ 70 m x 5 m), is constructed at this branch twice a year. In spring this barrier directs emigrating salmon seaward via the San Joaquin River, and in autumn it amplifies flows through the Stockton Ship channel to preclude oxygen sags that occur under stagnant hydraulic conditions (Figure 3C, Jones and Stokes 2005b). This barrier is removed each year during the wet season to protect local levees from flooding.

The linkage between barrier operations and oxygen dynamics is illustrated with monitoring data showing the progressive decrease of DO concentration in the Stockton ship channel, a deep section of the San Joaquin River downstream of the HORB, immediately after the barrier was removed on 15 November 2001 (Figure 7A). San Joaquin flows above and below the Old River junction during autumn 2002 illustrate the effect of this barrier on the routing of river inflow. The San Joaquin inflow (at Vernalis, Figure 2) was relatively steady (~45 $m^3 s^{-1}$) from mid-October to mid-December (Figure 7B). Similar-magnitude flows below the Old River branch (at Stockton, Figure 2) show that most of the San Joaquin inflow was, as intended, routed along the northerly transit when the HORB was in place. After the barrier was removed on 15 November, most San Joaquin inflow was routed into Old River and, as a result, the net flow at Stockton fell near or below zero (Figure 7B). These records reveal barrier-controlled modification of south Delta circulation, dominated by northerly San Joaquin flow (Figure 3C) when the head of Old River barrier is present, and westerly flow (Figure 3A) when it is absent.

The Stockton ship channel has chronic problems of DO depletion below 6 mg $L^{-1}$, the regulatory level set to protect biota sensitive to hypoxia (CVRWQCB 1998). Several studies have identified residence time as a key mechanism of hypoxia (Jassby and Van Nieuwenhuyse 2005, Jones and Stokes 2005a), but none have explicitly calculated transport time scales in the Stockton ship channel and their sensitivity to barrier placement and removal. Model simulations provide a tool for quantifying the hydraulic flushing rate of water in the Stockton Ship Channel under scenarios of HORB emplacement and removal.

We used Delta TRIM simulations driven with autumn 2001 and 2002 hydrologic conditions to compute flushing times in Stockton ship channel when the HORB is in place and removed. Neutrally buoyant particles were released in the Stockton ship channel. Particle trajectories and the number of particles remaining within the Stockton ship channel were recorded each hour. Because the phase of the tide at release time influences particle trajectories, 24 different initial release times were simulated for each day. Three hundred and fifteen particles were introduced at the beginning of each release time. We recorded the number of particles remaining in the Stockton ship channel hourly for 145 hours after release on 14 August 2002 (barrier in, Figure 7C) and 5 December 2002 (barrier out, Figure 7D).

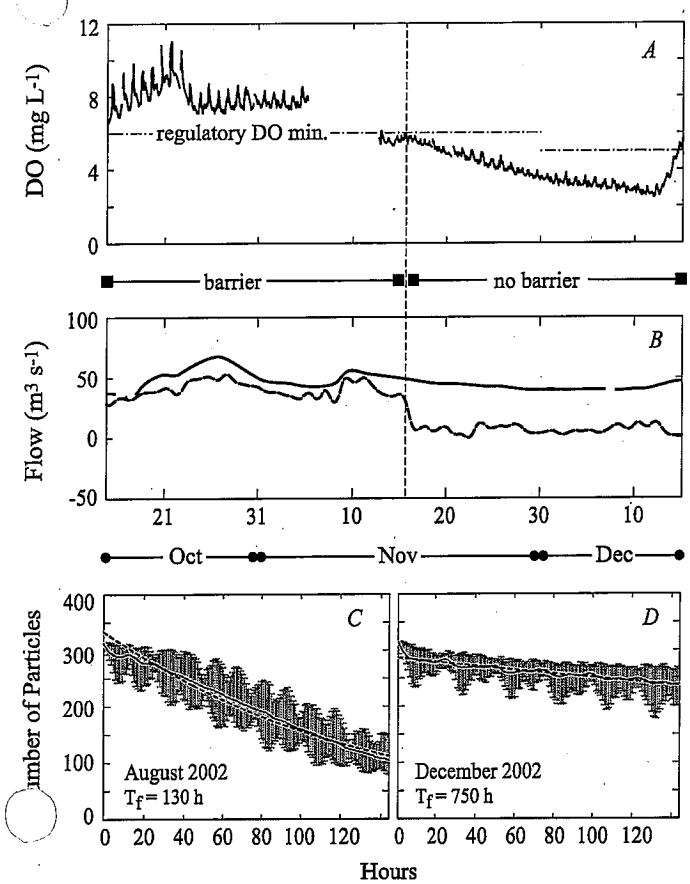



**Figure 7.** Influence of head of Old River barrier removal on DO concentrations in the Stockton Ship Channel during autumn 2002. (A) Dissolved oxygen 1 m below the surface in the Stockton Ship Channel at Rough and Ready Island; (B) San Joaquin flow at Vernalis (solid line) and tidally-averaged flow at Stockton (dashed line). (C-D) Model-based calculations of flushing time Tf for (C) August 2002 (Tf = 130 h) and (D) December 2002 (Tf = 750 h). Vertical bars represent the range of particle numbers remaining after t hours for all 24 simulations. The solid line represents the mean number of particles each hour. The dotted lines are time series of mean particle numbers from equation (4). Data sources: IEP database: dissolved oxygen (CDWR; Station: RSAN058) and San Joaquin flow (USGS; Station: RSAN063, RSAN112) and, CDWR Bay-Delta Office: Temporary barrier operating schedule (http://sdelta.water.ca.gov/web_pg/tempmesr.html).

These simulations showed > 5-fold increase in flushing time in the Stockton Ship Channel after the HORB was removed: in August 2002 (HORB in) the mean flushing time Tf was 130 h; in December 2002 (HORB out) Tf was 750 h. During early December, the tidally-averaged flow at Stockton was almost zero (Figure 7B). As a result, Tf calculated by the model during this period are highly sensitive to the model representation of tidally-averaged flow, which is underestimated by Delta TRIM because of poorly resolved bathymetry and model representation of the Old River-San Joaquin River junction. Therefore, Tf calculated for 5 December 2002 (Figure 7D) is best interpreted as an upper bound on the flushing time for this December 2002 period.

To test the sensitivity of model representation of flushing time with respect to San Joaquin flow, we did a second series of simulations forced with autumn 2001 hydrology when inflow at Vernalis was more variable, ranging from 40-60 $m^3 s^{-1}$. The flushing time for 8 August 2001 (HORB in) was 100 h, similar to the August 2002 simulation result. The flushing time for 5 December 2001 (HORB out) was 400 h, approximately half the value calculated for December 2002. In the December 2001 simulation, the tidally-averaged flow represented by the model at Stockton was close to the tidally-averaged flow measured in the December 2002 case. Therefore, $T_f$ calculated for December 2001 by the model is an estimate of the lower bound on flushing time in the Stockton Ship Channel for December 2002 hydrology when the HORB is removed.

Based on these simulations, we concluded that, as a rule of thumb, the flushing time for the Stockton Ship Channel during autumn periods is on the order of days when the HORB is in place, and on the order of weeks when this barrier is removed. The calculation of flushing time was highly sensitive to the model representation of tidally-averaged flow, especially in low flow conditions. As with any calculation of transport time, the specific values calculated by a model are only applicable to the specific time period simulated and should not be assumed as absolute values for all periods (Monsen et al. 2002).

## CONCLUSIONS: IMPLICATIONS FOR THE DELTA ECOSYSTEM

Diversions to meet society's demand for reliable water supply have often had surprising consequences. The Egyptian High Aswan Dam reduced nutrient inputs from the Nile to the Mediterranean Sea, resulting in

collapse of sardine and prawn fisheries (Nixon 2003). Diversions exposed the Aral Sea bed, creating salt and dust storms with catastrophic effects on human health and agricultural production (Micklin 1988). Levee construction around Colombia's Ciénaga Grande de Santa Marta cut off freshwater supplies and killed extensive areas of mangrove forest (Perdomo et al. 1998). Diversions along China's Yellow River caused the river to dry up approximately 600 km from the river's mouth, with no outflow for 226 days in 1997, causing seawater intrusion and wetland recession in the delta area (Cai and Rosegrant 2004).

Tools are available to anticipate environmental consequences of flow diversions, and our purpose here is to illustrate the application of hydrodynamic models to understand how different diversion types modify water source mixtures, flow paths, and rates. Each hydraulic effect has consequences for water quality, and we conclude with a discussion of how each might also drive changes in the capacity of the Delta ecosystem to sustain communities of native biota.

## Source Mixtures

Water quality in the Sacramento-San Joaquin Delta has an unusually large spatial heterogeneity because its subregions contain different mixtures of water from multiple origins, each having distinct chemical composition. We used monitoring data and a hydrodynamic model to illustrate how patterns of spatial heterogeneity change in response to gate and export diversions, using salinity as a tracer of river water from different sources. This approach can be expanded to learn how diversions alter the concentration fields of other chemical constituents such as land-derived pollutants. Selenium is a priority pollutant in San Francisco Bay, originating from mobilization of Se-enriched soils by irrigation in the San Joaquin River basin and accumulating in food webs downstream, leading to potentially toxic levels in consumers, including white sturgeon and Sacramento splittail (Stewart et al. 2004). Selenium concentrations are 8-85 times higher in the San Joaquin than the Sacramento River (Cutter and Cutter 2004), so the concentration of dissolved selenium across the Delta waterscape is expected to vary with the ratio of San Joaquin:Sacramento water. We can hypothesize that as diversions modify this ratio they alter selenium concentrations, just as they alter salinity distributions.

Processes that change concentration fields of pollutants are ecologically important because the toxicity and accumulation of pollutants in food webs are concentration dependent. The new pyrethroid pesticides are extremely toxic to invertebrates with sublethal effects at concentrations measured in parts per trillion (Oros and Werner 2005); the herbicide diuron inhibits phytoplankton photosynthesis in the Delta at concentrations > 2 $\mu g\ L^{-1}$ (Edmunds et al. 1999); phytoplankton accumulate methyl mercury at concentrations 10,000 times those in water (Davis et al. 2003); bioaccumulation of toxic metals (e.g. copper, cadmium, silver, chromium) in invertebrates and fish depends on concentrations of those elements in water and prey (Luoma and Rainbow 2005). We have learned empirically how individual diversions modify salt concentrations across the Delta, but we have not yet considered how they modify distributions of land-derived pollutants and their threats to wildlife or human health.

## Transport Routes

The Delta is an exceedingly complex network of channels, sloughs, and shallow open waters connected to a tidal estuary and large rivers. We used flow measurements and hydrodynamic simulations to illustrate how diversions, as intended, modify the routing of water through this network to meet multiple objectives. Pumped exports deliver fresh water to agricultural and municipal consumers; the Delta Cross Channel moves low-salinity Sacramento water into the central Delta and improves water quality delivered to exports and municipal intakes; seasonal barriers alter the routing of San Joaquin River water to facilitate fish migrations and prevent anoxia. The consequences of these altered flow routings are known for salinity and DO, but the broader suite of ecological consequences has not been explored systematically. This knowledge gap constrains our capacity for designing effective strategies to sustain or rehabilitate native species and their supporting ecological functions.

Some diversions, such as the HORB and DCC, are operated to direct the seaward or landward migrations of salmonids. However, other biological and ecological

responses to diversion-induced flow routings are poorly known and most have not yet been considered. Pumped exports and within-Delta diversions cause entrainment loss and increased predation of endangered/threatened species of fish such as Delta smelt (Bennett and Moyle 1996). A key uncertainty of the Delta ecosystem is the extent to which diversion-induced mortality contributes to population declines of native biota. Recent analyses show that routing paths matter: entrainment (salvage) of juvenile and adult Delta smelt at the SWP and CVP are strongly correlated with combined flows in Old River and Middle River (Smith et al. 2006).

Flow routings have potentially large impacts on ecosystem functions, such as primary and secondary production in pelagic food webs that sustain native fish. Agricultural diversions and pumped exports remove phytoplankton biomass equivalent to 30% of annual within-Delta primary production (Jassby et al. 2002). This loss at the food web base reduces the Delta's carrying capacity for consumers in this low-productivity ecosystem where food limitation is pervasive across trophic levels (Lopez et al. 2006), and it significantly reduces the supply of algal-derived organic matter from the Delta to the San Francisco Estuary (Jassby et al. 2000). Diversion-induced alterations of hydraulic exchange across habitats (Figure 4c) may also alter production efficiency. Modeling analyses indicate that overall ecosystem primary and secondary production increase in proportion to the transport rate of algal food supplies from shallow donor habitats, such as Mildred Island to deep recipient channel habitats (Cloern 2007).

## Flushing Time

We also used the hydrodynamic model to illustrate how diversions modify flushing time, an index of water replacement rate within individual habitats. The seasonal depletion of dissolved oxygen in the San Joaquin River at Stockton shows how water quality is influenced by the balance between rates of competing processes: microbial metabolism that removes oxygen and advective-dispersive replacement of oxygen-deficient water with oxygenated water. Model simulations show that DO depletion occurs in the Stockton Ship Channel when the flushing time is longer than several weeks, but not when the flushing time is less than one week (Figure 7). This result is consistent with BOD measurements indicating that the half life of oxygen-consuming constituents is about 12-15 days in the lower San Joaquin River (Volkmar and Dahlgren 2006). Flushing times longer than this characteristic time of oxygen consumption lead to local oxygen depletions. DO depletions are critical habitat degradations because they can be direct causes of mortality or impede migrations of salmonids (Jassby and Van Nieuwenhuyse 2005).

The DO example illustrates how the dynamics of reactive constituents are determined by time scales of both transport and biogeochemical reactions, and how these dynamics become dominated by biogeochemical transformations as transport time scales are lengthened by water diversions. Transport time scales are critical attributes of aquatic ecosystems (Monsen et al. 2002) and we expect that many other components of water quality respond when diversions alter transport rates. Massive algal blooms develop in the lower San Joaquin River under low-flow conditions of long flushing time (Jassby 2005). Detailed mapping across Mildred Island revealed significant spatial variability characterized by highest water temperatures and highest phytoplankton biomass within side embayments isolated from strong tides and having long residence time (Lucas et al. 2006). These retentive, high-biomass subhabitats are zones of enhanced algal and bacterial assimilation of dissolved selenium and transformation into particulate forms available to consumers (Baines et al. 2004). The Delta functions as a biogeochemical transformer of reactive substances as they are transported from land runoff to San Francisco Bay. For example, the Delta removes 60-80% of the river input of dissolved selenium, and this removal efficiency decreases as the water residence time decreases (Meseck and Cutter 2006). Therefore, hydraulic manipulations that lengthen (shorten) flushing time will amplify (diminish) the magnitude of biogeochemical transformations, and therefore modify the net downstream transport of contaminants and other reactive constituents to San Francisco Bay.

### Toward a Vision of the Delta's Future

Ecosystem frameworks for water management consider the full suite of costs and benefits of flow manipulation, and these frameworks become more urgent as the world population and scale of water development continue to grow. Water withdrawals for food production are projected to increase 14% in the next 30 years, expanding irrigated land by 450,000 km$^2$ in 93 developing countries (World Water Assessment Programme 2003). Allocations of water for agriculture will also increasingly compete with municipal demands and water allotments for ecosystem sustainability in California, with particular focus in the Sacramento-San Joaquin Delta. Innovative resource managers are searching for means to implement Integrated Water Resources Management in which development of water, land, and related resources are coordinated to maximize economic and social welfare "without compromising the sustainability of vital ecosystems" (World Water Assessment Programme 2003). Our purpose here is to highlight the critical importance of understanding how flow manipulations alter hydraulics, water quality, habitat quality, and sustainability of the Delta ecosystem, and to illustrate how hydrodynamic models can be used as one tool set to assess the ecosystem-scale consequences of scenarios as we produce a vision for the twenty-first century Delta (Mount et al. 2006).

## ACKNOWLEDGEMENTS

This study was supported by the US Geological Survey's Toxic Substances Hydrology Program, Priority Ecosystems Science Program, by the CALFED Science Program (Contract #460001679, #01AA200103), and by the CALFED Ecosystem Restoration Program (Contract #4600001955). Special thanks to Lisa Lucas for many discussions during the development of this manuscript; and to the many people involved in the Mildred Island field study that originally prompted this analysis. Reviews by A. Robin Stewart, Noah Knowles, Heather Peterson, Kate Dallas, and Tara Schraga (USGS), and three anonymous reviews greatly improved this manuscript.

## REFERENCES

Atwater, BF, Conard SG, Dowden JN, Hedel CW, MacDonald RL, Savage W. 1979. History, landforms, and vegetation of the estuary's tidal marshes. In: Conomos TJ, editor. San Francisco Bay, The Urbanized Estuary. San Francisco: Pacific Division, American Association for the Advancement of Science. p. 347-385.

Baines SB, Fisher NS, Doblin MA, Cutter GA, Cutter LS, Cole B. 2004. Light dependence of selenium uptake by phytoplankton and implications for predicting selenium incorporation into food webs. Limnology and Oceanography 49:566-578.

Bennett WA, Moyle PB. 1996. Where have all the fishes gones? Interactive factors producing fish declines in the Sacramento-San Joaquin Estuary. In: Hollibaugh JT, editor. San Francisco Bay: the ecosystem. San Francisco: Pacific Division, American Association for the Advancement of Science. p. 519-542.

Cai X, Rosegrant MW. 2004. Optional water development strategies for the Yellow River Basin: Balancing agricultural and ecological water demands. Water Resources Research 40:W08S04.

[CDFA] California Department of Food and Agriculture. 2002. Resource directory. Sacramento (CA): California Department of Food and Agriculture.

[CDWR] California Department of Water Resources. 1998. California water plan update. Sacramento (CA): California Department of Water Resources. Bulletin 160-98. 720 p.

[CDWR] California Department of Water Resources. 2001. Management of the California State Water Project. Sacramento (CA): California Department of Water Resources. Bulletin 132-00. 324 p.

[CDWR] California Department of Water Resources. 2003. The Municipal Water Quality Investigations Program summary and findings from data collected August 1998 through September 2001. Sacramento (CA): California Department of Water Resources Division of Environmental Services.

Casulli V, Cattani E. 1994. Stability, accuracy and efficiency of a semi-implicit method for three-dimensional shallow water flow. Comput Math Appl 27:99-112.

/RWQCB] Central Valley Regional Water Quality Control Board. 1998. The water quality control plan for the Sacramento River Basin and the San Joaquin River Basin. 4th ed. Sacramento (CA): Central Valley Regional Water Quality Control Board.

Cheng RT, Casulli V, Gartner JW. 1993. Tidal, residual, intertidal mudflat (TRIM) model and its applications to San Francisco Bay, California. Estuarine, Coastal and Shelf Science 49:647-665.

Cloern JE. 2007. Habitat connectivity and ecosystem productivity: implications from a simple model. The American Naturalist 169: E21-E33.

Cutter GA, Cutter LS. 2004. Selenium biogeochemistry in the San Francisco Bay estuary: changes in water column behavior. Estuarine, Coastal and Shelf Science 61:463-476.

Davis JA, Yee D, Collins JN, Schwarzbach SE, Luoma SN. 2003. Potential for increased mercury accumulation in the estuary food web. San Francisco Estuary and Watershed Science. Vol. 1, Issue 1 (October 2003), Article 4. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art4

hunds JL, Kuivila KM, Cole BE, Cloern JE. 1999. Do Herbicides Impair Phytoplankton Primary Production in the Sacramento-San Joaquin River Delta? in Morganwalp DW, Buxton HT, eds., U.S. Geological Survey Toxic Substances Hydrology Program Proceedings of the Technical Meeting, Charleston, South Carolina, March 8 12, 1999 Volume 2 of 3 Contamination of Hydrologic Systems and Related Ecosystems: U.S. Geological Survey Water Resources Investigations Report 99 4018B, pp. 81-88.

Fischer HB, List EJ, Koh RCY, Imberger J, Brooks NH. 1979. Mixing in inland and coastal waters. San Diego: Academic Press, Inc.

Gross ES, Koseff JR, and Monismith SG. 1999. Three-dimensional salinity simulations of South San Francisco Bay. J Hydraul Eng 25:1199-1209.

Herren JR, Kawasaki SS. 2001. Inventory of water diversions in four geographic areas in California's Central Valley. In Brown RL, editor. Contributions to the biology of Central Valley Salmonids, Volume 2. Sacramento (CA): California Department of Fish and ne. Fish Bulletin 179. p. 343-355.

Jassby AD, Cloern JE. 2000. Organic matter sources and rehabilitation of the Sacramento-San Joaquin Delta (California, USA). Aquatic Conservation: Marine and Freshwater Ecosystems 10:323-352.

Jassby AD, Cloern JE, Cole BE. 2002. Annual primary production: Patterns and mechanisms of change in a nutrient-rich tidal ecosystem. Limnology and Oceanography 47:698-712.

Jassby AD. 2005. Phytoplankton regulation in a eutrophic tidal river (San Joaquin River, California). San Francisco Estuary and Watershed Science. Vol. 3, Issue 1 (March 2005), Article 3. http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art3

Jassby A, Van Nieuwenhuyse EE. 2005. Low dissolved oxygen in an estuarine channel (San Joaquin River, California): mechanisms and models based on long-term time series. San Francisco Estuary and Watershed Science. Vol. 3, Issue 2 (September 2005), Article 2. http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art2

Jones and Stokes. 2005a. Preliminary Draft Conceptual Model for Dissolved Oxygen in the San Joaquin River.

Jones and Stokes. 2005b. South Delta Improvements Program Volume I: Environmental Impact Statement/Environmental Impact Report-Draft, State Clearinghouse #2002092065.

Lopez CB, Cloern JE, Schraga TS, Little AJ, Lucas LV, Thompson JK, Burau JR. 2006. Ecological values of shallow-water habitats: implications for the restoration of disturbed ecosystems. Ecosystems 9:422-440.

Lucas LV, Cloern JE, Thompson JK, Monsen NE. 2002. Functional variability of habitats within the Sacramento-San Joaquin Delta: restoration implications. Ecological Applications 12:1528-1547.

Lucas LV, Sereno DM, Burau JR, Schraga TS, Lopez CB, Stacey MT, Parchevsky KV, Parchevsky VP. 2006. Intratidal variability of water quality in a shallow tidal lagoon: mechanisms and implications. Estuaries 29:711-730.

Luoma SN, Rainbow PS. 2005. Why is metal bioaccumulation so variable? Biodynamics as a unifying concept. Environmental Science and Technology 39:1921-1931.

Meseck SL, Cutter GA. 2006. Evaluating the biogeochemical cycle of selenium in San Francisco Bay through modeling. Limnology and Oceanography 51:2018-2032.

Micklin PP. 1988. Desiccation of the Aral Sea: a water management disaster in the Soviet Union. Science 241:1170-1176.

Monsen NE. 2001. A study of sub-tidal transport in Suisun Bay and the Sacramento-San Joaquin Delta, California [dissertation]. Stanford (CA): Stanford University. 345 p.

Monsen NE, Cloern JE, Lucas LV, Monismith, SG. 2002. A comment on the use of flushing time, residence time, and age as transport time scales. Limnol Oceanogr 47(5):1545-1553.

Mount J, Twiss R, Adams RM. 2006. The Role of Science in the Delta Visioning Process: A report of the Delta Science Panel of the CALFED Science Program. Available from: http://science.calwater.ca.gov/

Nixon SW. 2003. Replacing the Nile: Are anthropogenic nutrients providing the fertility once brought to the Mediterranean by a great river? Ambio 32:30-39.

Oros DR, Werner I. 2005. Pyrethroid Insecticides: An Analysis of Use Patterns, Distributions, Potential Toxicity and Fate in the Sacramento-San Joaquin Delta and Central Valley. White Paper for the Interagency Ecological Program. SFEI Contribution 415. San Francisco Estuary Institute, Oakland, CA. http://www.sfei.org/cmr/reports/415_Pyrethroids_WhitePaper_FINAL.pdf

Perdomo L, Ensminger I, Espinosa LF, Elster C, Wallner-Kersanach M, and Schnetter M. 1998. The mangrove ecosystem of the Ciénaga Grande de Santa Marta (Colombia): Observations on regeneration and trace metals in sediment. Marine Pollution Bulletin 37:393-403.

Simpson MR, Oltmann RN. 1993. Discharge measurement using an acoustic Doppler current profiler. Reston(VA): US Geological Survey. Water-Supply Paper 2395, 34 p.

Smith PE, Ruhl CA, Simi J. 2006. Hydrodynamic influences on historical patterns in Delta smelt salvage. In Abstracts: 7th Biennial CALFED Science Conference 2006, p. 206.

Standard Methods for the Examination of Water and Wastewater, 19th Edition. 1995. Washington (DC): American Public Health Association.

Stewart AR, Luoma SN, Schlekat CE, Doblin MA and Hieb KA. 2004. Food web pathway determines how selenium affects aquatic ecosystems: A San Francisco Bay case study. Environmental Science and Technology 38:4519-4526.

World Water Assessment Programme. 2003. United Nations World Water Development Report. Paris: UNESCO Publishing.

Volkmar EC, Dahlgren RA. 2006. Biological oxygen demand dynamics in the lower San Joaquin River, California. Environ. Sci. technol. 40:5653-5660.

Attachment 17

# TRACY FISH FACILITY STUDIES
# CALIFORNIA

Volume 11

## Empirical and Experimental Analyses of Secondary Louver Efficiency at the Tracy Fish Collection Facility: March 1996 to November 1997

by

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Fish photography by Rene Reyes, Tracy Fish Collection Facility, Tracy, California.
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# TABLE OF CONTENTS

Page

**Executive Summary** ..... **vii**

**Introduction** ..... **1**
Secondary Louver Efficiency ..... 5

**Methodology** ..... **5**
Secondary Louver Efficiency ..... 5
Splittail Injection Experiments ..... 7
Delta Smelt Recommendation ..... 9

**Results** ..... **9**
Delta Smelt Recommendation ..... 26

**Discussion** ..... **28**

**Conclusions** ..... **31**

**Acknowledgments** ..... **32**

**References** ..... **32**

## Figures

*Figures* *Page*

1 The Sacramento-San Joaquin Delta with the location of the TFCF indicated. ..... 2
2 Schematic of the TFCF. ..... 3
3 The secondary channel at the TFCF. Sieve net and splittail injection locations are indicated. ..... 4
4 Frequency distribution of secondary louver efficiency observations for (a) American shad, (b) threadfin shad, (c) Sacramento blackfish, and (d) splittail at the TFCF, March 1996 – November 1997. ..... 20
5 Frequency distribution of secondary louver efficiency observations for (a) Sacramento sucker, (b) white catfish, (c) channel catfish, and (d) delta smelt at the TFCF, March 1996 – November 1997. ..... 21

## Table of Contents—continued

### Figures—continued

*Figures* *Page*

6 Frequency distribution of secondary louver efficiency observations for (a) longfin smelt, (b) chinook salmon, (c) inland silverside, and (d) prickly sculpin at the TFCF, March 1996 – November 1997. . . . . 22
7 Frequency distribution of secondary louver efficiency observations for (a) striped bass, (b) warmouth, (c) bluegill, and (d) largemouth bass at the TFCF, March 1996 – November 1997. . . . . 23
8 Frequency distribution of secondary louver efficiency observations for (a) black crappie, (b) bigscale logperch, (c) yellowfin goby, and (d) shimofuri goby at the TFCF, March 1996 – November 1997. . . . . 24
9 Distribution of splittail secondary louver efficiency during injection experiments. . . . . 25
10 Three dimensional velocity profile in front of the anterior louver array with (a) no net, (b) the control net, and (c) the experimental debris net in place. The velocity probe was placed 5.1 cm (2 in) from the louver array surface. . . . . 27
11 Predicted secondary louver efficiency for delta smelt given channel approach velocity. These predications were made using Probit analysis to generate the mean and confidence limits predicted at a particular channel velocity. (See page 9.) . . . . . 28

### Tables

*Tables* *Page*

1 Range of secondary louver efficiencies observed at the TFCF, Tracy, California, from 1955 to present . . . . . 5
2 Environmental and operational parameters recorded with simultaneous holding tank/sieve net observations at the TFCF . . . . . 6
3 Factorial design executed in the splittail injection experiments. The number in each cell represents the number of replicates completed for each combination . . . . . 8
4 Grand secondary louver efficiency (see equation on page 6) of individuals successfully salvaged at the TFCF, Tracy, California, from March 1996 – November 1997. Order of fishes follows AFS (1991) . . . . . 10
5 Logistic regression analysis of the effects of three independent variables' on secondary louver efficiency at the TFCF, Tracy, California, from March 1996 – November 1997. Number of simultaneous 10-minute holding tank/sieve net samples were: splittail ($n$ = 121), delta smelt ($n$ = 149), chinook salmon ($n$ = 196), and striped bass ($n$ = 253) . . . . . 11

## Table of Contents—continued

### Tables—continued


| Tables | | Page |
|---|---|---|
| 6 | Secondary louver efficiency in three approach-velocity categories for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997 | 13 |
| 7 | Secondary louver efficiency at three periods of day for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997. Crepuscular period data combine dawn and dusk samples | 14 |
| 8 | Secondary louver efficiency at three debris levels for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997. Debris mass was obtained in the holding tank during a 10-min simultaneous holding tank/sieve net sample | 15 |
| 9 | Secondary louver efficiency at three temperature ranges for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997 | 16 |
| 10 | Secondary louver efficiency in three bypass ratio categories for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997 | 17 |
| 11 | Secondary louver efficiency at three tidal states for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997. Slack tide is the 6-h period between sequential tidal peaks | 18 |
| 12 | Net experimental louver efficiency for splittail released in the secondary channel at the TFCF, March 1999 – May 1999. Superscripts indicate statistically significant difference via Two-Way, Model I ANOVA and planned comparison of means | 26 |
| 13-1 | Louver efficiency for those splittail released in front of both secondary louver arrays at the TFCF, March 1999 – May 1999 | 29 |
| 13-2 | Louver efficiency for those splittail released between the secondary louver arrays | 30 |
| 14 | Percentage of two size ranges of target species successfully louvered at the TFCF March 1996 – November 1997 | 30 |
| 15 | Proposed changes to operations for secondary louver channel at the TFCF. The recommended secondary channel approach velocity appears on the same line as the species for which the recommendation is intended. Justification for these recommended velocities appears in this section and the Results section | 31 |

# EXECUTIVE SUMMARY

The Tracy Fish Collection Facility (TFCF) was completed in 1954 to salvage primarily chinook salmon and striped bass. An assessment of TFCF secondary louver efficiency in the late 1950s (Bates et al., 1960) showed louver efficiency for chinook salmon was between 92 and 100 percent; louver efficiency for striped bass was between 86 and 95 percent. By the early 1990s (Karp et al., 1995), louver efficiency for both of these species had deteriorated. In this report, the current secondary louver efficiency is evaluated for chinook salmon, striped bass, and 31 other species of fish.

Secondary louver efficiency was determined by simultaneously obtaining louvered fish in the holding tank and catching fish slipping through the louvers with a sieve net deployed behind the secondary louvers. We found the secondary louver efficiency had not improved since the early 1990s: (1) efficiency for chinook salmon averaged 85.1 percent and (2) efficiency for striped bass averaged 61.6 percent. Multivariate statistical analysis found only one significant relationship between any of three independent variables (average channel velocity, time of day, and debris load) studied and secondary louver efficiency. Average channel velocity varied positively with secondary louver efficiency of chinook salmon. However the relationship was not a strong one; average channel velocity cannot predict chinook salmon secondary louver efficiency.

No independent variable influenced delta smelt average channel velocity in a statistically significant manner. However, careful observation indicated one factor that varied inversely with delta smelt louver efficiency. When average channel velocity was less than or equal to 1.09 feet per second (ft/s) delta smelt louver efficiency was 82.5 percent. When average channel velocity was between 1.09 and 3.1 ft/s, delta smelt louver efficiency was 64.0 percent. When average channel velocity was greater than or equal to 3.1 ft/s, delta smelt louver efficiency was 13.0 percent. Because of this result and others detailed in the report, it is recommended that the average velocity in the secondary channel be maintained at 1.09 ft/s year-round except when chinook salmon are present at the TFCF. When chinook salmon are present, it is recommended that average velocity in the secondary channel be maintained at 3.1 ft/s.

Experiments were conducted to evaluate the influence of debris load on splittail secondary louver efficiency. An extremely heavy debris load was

simulated with a special experimental net. With the net in place, splittail were inserted into the secondary channel. Splittail secondary louver efficiency was significantly lower when the net was present during the day, but there was no difference at night. This suggests that louver efficiency is decreased when splittail can see the debris during the day. The experimental approach was found to be effective in determining the influences on louver efficiency. It is suggested that future research at the TFCF use this experimental approach to supplement the classical empirical approach.

# INTRODUCTION

California's Central Valley Project moves water from the Sacramento River watershed south to the San Joaquin Valley (figure 1) and more southern localities. At the Federal south-Delta diversion point, the U.S. Department of the Interior (Interior), Bureau of Reclamation (Reclamation) operates the Tracy Fish Collection Facility (TFCF). After tests of various fish screens (U.S. Department of the Interior, 1957), Reclamation selected a system in which fish salvage is performed (figure 2) by a system of louvers and bypasses as water passes through the TFCF and into the Delta-Mendota Intake Canal (DMC). The DMC transports water to the Tracy Pumping Plant (TPP), where the water is lifted and then travels by gravity south for agricultural and domestic uses.

The fish salvage at the TFCF is accomplished in two louver channels. The primary channel has a maximum depth of 6 meters (m) (20 feet [ft]) and is completely traversed by the primary louver array, which is 97.5 m (320 ft) long and 25.6 m (84 ft) wide (figure 2). The louver array is angled 15 degrees to the channel and has four bypasses. Each bypass is 15.3 centimeters (cm) (6 inches [in]) wide and leads to a primary bypass pipe 91.4 cm (36 in) in diameter. These four pipes deliver water to the secondary louver channel.

The secondary louver channel has a maximum depth of 4.9 m (16 ft) and contains two parallel louver arrays that span the channel's entire 2.4 m (8 ft) width. Similar to the primary louvers, both secondary louver arrays are angled 15 degrees to the flow. The anterior louver array in the secondary channel ends in a rectangular opening. This steel "bypass" is 15.3 cm (6 in) wide. However, this is not a bypass to a holding tank (figure 3); the steel ends 1.7 m (5.6 ft) in front of the posterior louver array's true bypass (width = 15.3 cm [6 in]). A fish could be "louvered" by the anterior secondary louver array and potentially swim through the posterior secondary louver array and be transported into the DMC.

Each louver array consists of a series of vertical slats spaced 2.3 cm (0.9 in) apart. The louver slats create a visual and turbulent barrier to fish. Most fish swim against the current but are eventually transported downstream. When a fish encounters the louver array it tends to swim laterally away from the turbulence into the more laminar flow. Thus, fish are "guided" toward the bypass.

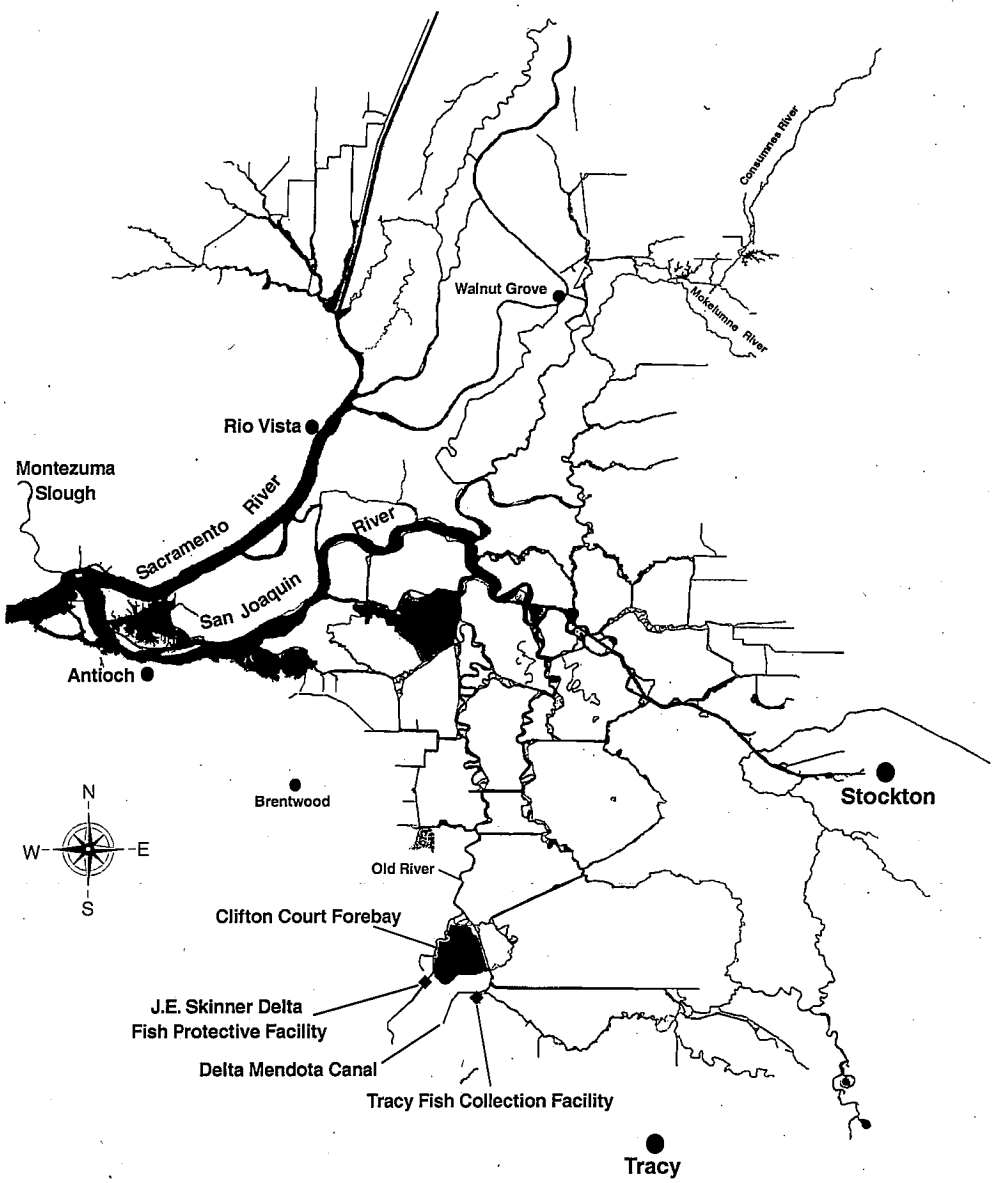



FIGURE 1.—The Sacramento-San Joaquin Delta with the location of the TFCF indicated.

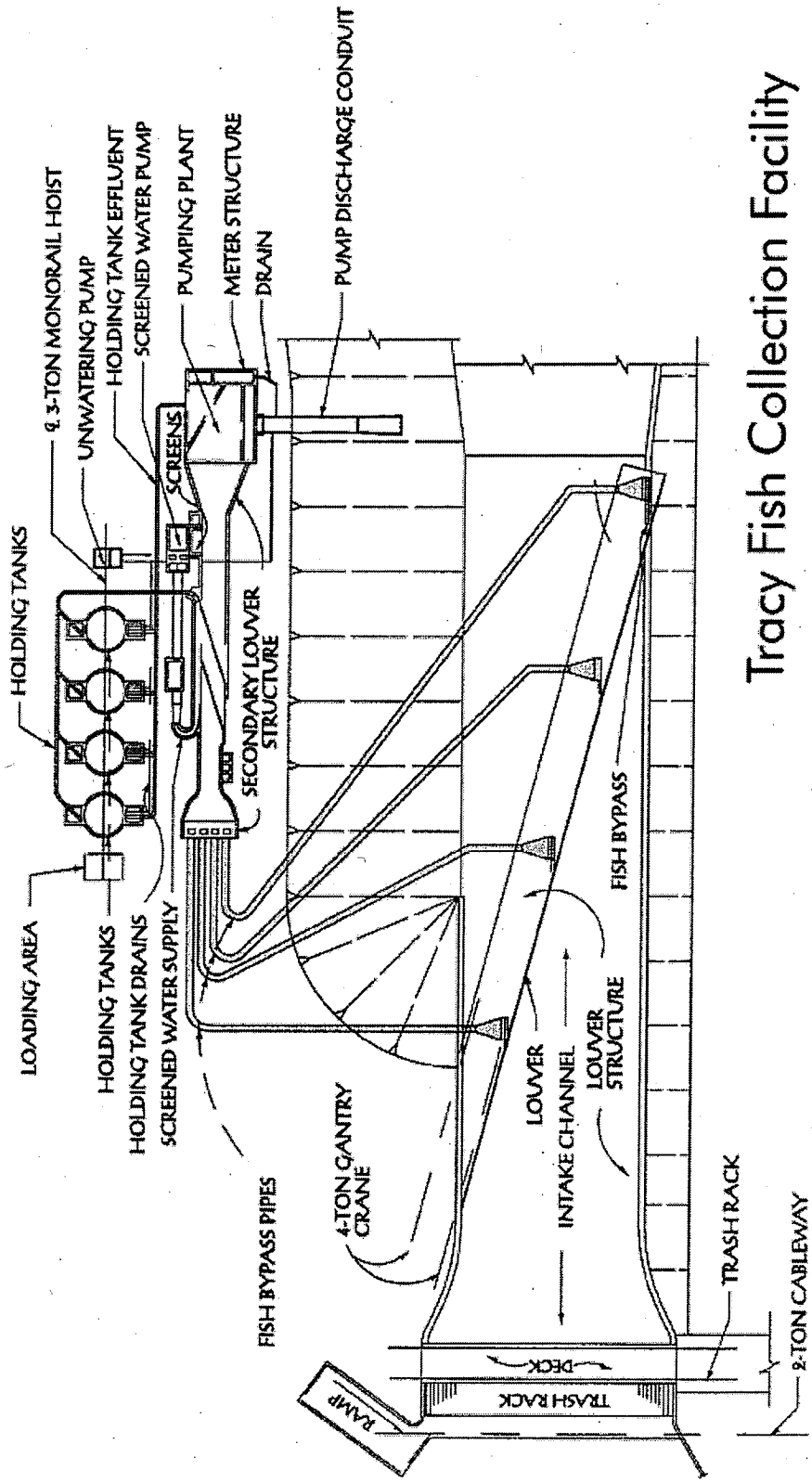



FIGURE 2.—Schematic of the TFCF.

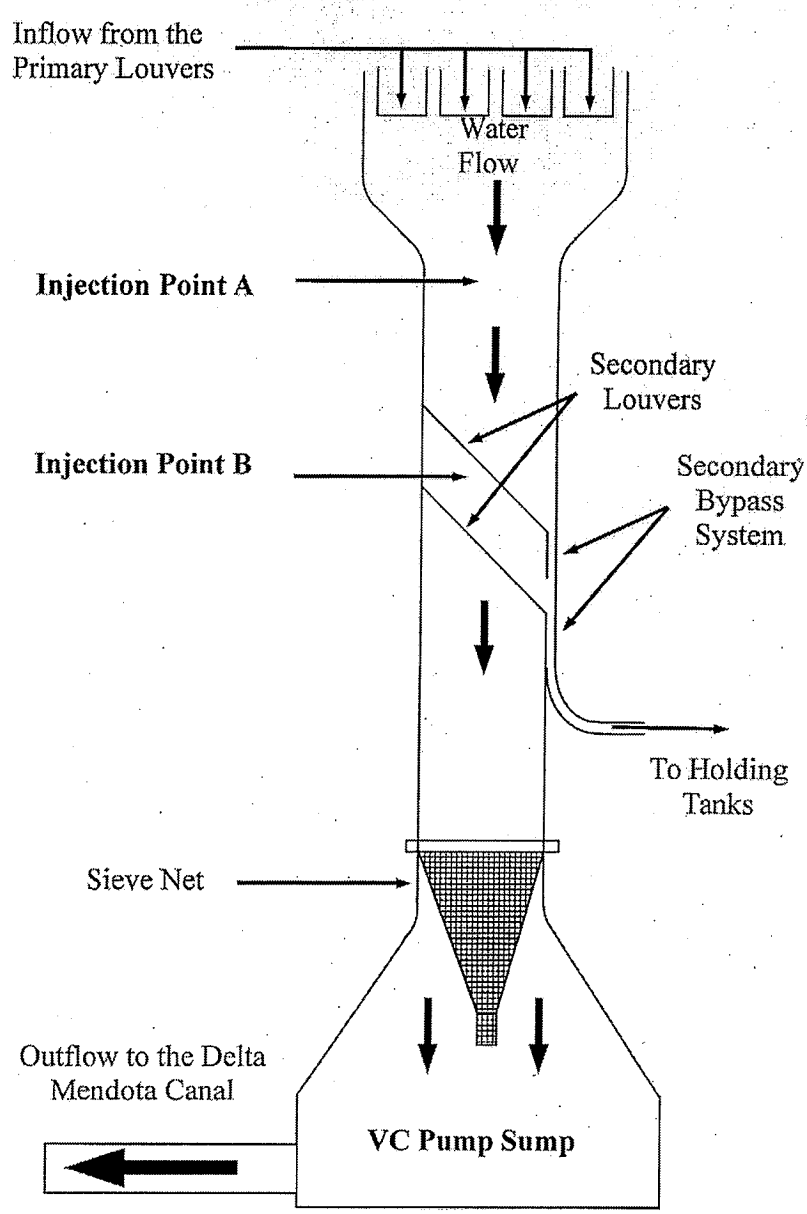



FIGURE 3.—The secondary channel at the TFCF. Sieve net and splittail injection locations are indicated.

## Secondary Louver Efficiency

Since the completion of the TFCF, secondary louver efficiency has apparently decreased for the two target species for which the facility was primarily constructed: juvenile chinook salmon, *Oncorhynchus tshawytscha*, and juvenile striped bass, *Morone saxatilis* (table 1). We began this study to determine if this decrease was continuing and to investigate the influence of time of day, channel approach velocity, and louver debris load on secondary louver efficiency. After collecting many empirical observations of efficiency, we conducted experiments to evaluate the influence of time of day and louver debris load on splittail, *Pogonichthys macrolepidotus*, louver efficiency. Thus, we were able to compare empirical and experimental approaches to the study of secondary louver efficiency.

TABLE 1.—Range of secondary louver efficiencies observed at the TFCF, Tracy, California, from 1955 to present

| | Chinook Salmon Efficiency, Lower Range Limit | Chinook Salmon Efficiency, Upper Range Limit |
|---|---|---|
| Bates et al., 1960 | 92 | 100 |
| Karp et al., 1995 | 72 | 100 |
| Bowen et al., 1998 | 83 | 85 |
| | Striped Bass Efficiency, Lower Range Limit | Striped Bass Efficiency, Upper Range Limit |
| Bates et al., 1960 | 86 | 95 |
| Karp et al., 1995 | 44 | 90 |
| Bowen et al., 1998 | 61 | 86 |

# METHODOLOGY

## Secondary Louver Efficiency

We constructed a sieve net (2 millimeters [mm] [0.08 in] mesh) on a frame posterior to the two secondary louver arrays (figure 3). For 10 minutes (min), we simultaneously deployed the sieve net in the channel and directed flow from the bypass into a holding tank (effective mesh size 6 mm [0.25 in]). At the end of 10 min, we redirected flow into another holding tank and withdrew

the sieve net. Fish and debris were removed from the holding tank and sieve net.

The holding tank and sieve netted fish were then identified to species, and fork length (FL) was measured to the nearest mm (0.04 in). Species, lengths, and numbers of fish were recorded with operational and environmental parameters (table 2). For each 10-min observation, instantaneous secondary louver efficiency was calculated as:

$$E_i = H_i \quad (H_i + S_i)^{-1}$$

where,

$E_i$ = Instantaneous secondary louver efficiency
$H_i$ = Number of fish in the holding tank
$S_i$ = Number of fish in the sieve net

TABLE 2.—Environmental and operational parameters recorded with simultaneous holding tank/sieve net observations at the TFCF

| Operational | Environmental |
|---|---|
| Number of pumps operating at the TPP | Tide: out, in, slack |
| Primary channel discharge | Primary depth |
| Secondary channel discharge | Secondary depth |
| Primary channel velocity | Time of day |
| Secondary channel velocity | Debris load |
| Primary bypass ratio | Temperature |
| Secondary bypass ratio | Conductivity |
| Holding tank discharge | Salinity |
| VC pump combination | |
| Screen water (always off) | |

We recognize that this instantaneous efficiency places more weight on fish that enter the secondary louver channel alone ($n = 1$) than on fish that enter in a group.

To account for this, grand secondary louver efficiency was calculated as:

$$E_g = H_g \quad (H_g + S_g)^{-1}$$

where,

| | | |
|---|---|---|
| $E_g$ | = | Grand secondary louver efficiency |
| $H_g$ | = | Number of fish in the holding tank for all 10-min samples combined |
| $S_g$ | = | Number of fish in the sieve net for all 10-min samples combined |

## Splittail Injection Experiments

Two controls and one treatment were conducted. The first control was no net on the secondary louver array. The second control was a cotton net (mesh size of 25.6 mm [1 in]) weighted with rebar, 12.8 mm (0.5 in) in diameter, on the bottom of the net. The treatment was a cotton net, a duplicate of the control net, altered to simulate an extremely heavy debris load on the anterior secondary louver.

The treatment net was prepared with a cotton net, mesh size of 25.6 mm (1 in), on which was assembled plastic simulated vegetation and a plastic sheet. First, rebar 12.8 mm (0.5 in) in diameter was affixed to the bottom of the cotton net with cable ties to weight the bottom of the net. Second, 2,000 simulated vegetation clusters were affixed to the front of the cotton net with binder clips. Third, a plastic sheet was attached to the back of the net. From the plastic sheet, pieces were removed at random in three shapes: square, rectangular, and circular. The shapes were cut in three sizes: 0.09, 0.18, and 0.72 square meter ($m^2$) (1, 2, and 8 square feet [$ft^2$]). Pieces were removed until 17 percent of the plastic had been removed.

In a trial, no net, the control net, or the treatment net was affixed to the anterior secondary louver array. In addition, when the treatment net was in place, a perforated plate (3.7 m by 0.9 m (10 ft by 3 ft) with holes 2 mm (0.08 in) in diameter was situated on the last 0.9 m (3 ft) of the anterior secondary louver array. Thus, no fish could pass through the louver array in the 0.9 m (3 ft) closest to the bypass entrance. This perforated plate simulated the debris clogging that occurs near the bypass during heavy debris loading. We conducted a factorial design (table 3) with time of day

TABLE 3.—Factorial design executed in the splittail injection experiments. The number in each cell represents the number of replicates completed for each combination

| Treatment | Day | Night |
|---|---|---|
| No net | 3 | 3 |
| Control net | 4 | 2 |
| Vegetation net | 3 | 3 |

and the debris load treatments. All treatments began 1 hour (h) after high tide and each treatment was 3 h in duration. We also conducted three dimensional velocity profiles 91 cm (3 ft) along the front of the anterior louver with no net, the control net, and the experimental net in place.

In the spring of 1998, 1,440 splittail were retained from holding tank collections. For each experimental trial, 80 splittail (mean FL of 7 cm [3 in]) were prepared. Forty splittail were dyed with Bismarck brown for 3 h with 0.45 gram (g) of Bismarck brown in 220 liters (L) (100 gallons [gal]) of water. These 40 splittail then received a clip on the lower lobe of the caudal fin. Forty undyed splittail received a clip on the upper lobe of the caudal fin. One hour after high tide, the 40 dyed, clipped splittail were released by minnow bucket immediately downstream from the anterior secondary louver array. Hence, these fish were released between the two secondary louver arrays. The 40 undyed, clipped splittail were released 10 m (32.6 ft) upstream from the leading edge of the anterior louver array.

One hour after injection, and at the end of each hour during the trial, the sieve net was raised and all fish and debris were removed. Thus, the sieve net was out of the water for an average of 4 min every hour. This produced a slight overestimate of splittail secondary louver efficiency. We corrected for this effect by calculating the catch rate in the sieve net per minute. Then, we added the number of fish that would have been obtained in that 4 min. This discrepancy could not be avoided; when the sieve net was left in place for the entire 3-h duration of a trial, it was ripped by extensive accumulations of materials such as woody debris, plastics, and fish.

## Delta Smelt Recommendation

Using logistic regression, we modeled delta smelt secondary louver efficiency as a function of approach velocity. Delta smelt louver efficiency was defined as instantaneous louver efficiency (see equation page 6) and can also be interpreted as the probability of a delta smelt being successfully louvered into a holding tank. Calculations were performed using PROC PROBIT in SAS/STAT Release 8.02 (SAS Institute Inc., 1999-2001). Using the logistic regression model, we estimated the approach velocity that is associated with a given secondary louver efficiency; this problem is one of inverse prediction, i.e., prediction of the independent variable (approach velocity) from the dependent variable (delta smelt secondary louver efficiency). Using the INVERSECL option, we obtained 95 percent inverse confidence limits for a value of velocity that yields a given louver efficiency. The inverse confidence limits indicate the precision in our estimate of that velocity. We graphed the lower inverse confidence limit for several efficiencies (figure 11) because the lower limit is a conservative estimate of the minimum velocity needed to achieve a given efficiency.

# RESULTS

Between March 15, 1996, and November 9, 1997, we collected 26,539 fish representing 33 species of fish. These fish were obtained through 456 simultaneous 10-min holding tank/sieve net samples. Grand efficiency was calculated for each species (table 4).

Between March 1996 and November 1997, juvenile chinook salmon secondary louver efficiency was 85.1 percent; juvenile striped bass louver efficiency was 61.5 percent. The apparent reduction from the average 1960 (Bates et al., 1960) levels of louver efficiency noted in earlier studies (table 1) is still in effect for these two species.

Because of the bimodal distribution of empirical efficiency data (Bowen et al., 1998), we relied on logistic regression (Hosmer and Lemeshow, 1989) and Probit Analysis (SAS Institute Inc., 1999-2001) to evaluate the influence of channel approach velocity, time of day, and debris loading. With logistic regression, we found that juvenile chinook secondary salvage efficiency was positively influenced by channel approach velocity in the secondary channel (table 5: Probability of the Logistic Model Fit, $P = 0.7536$; Probability that Approach Velocity Explains No Variation, $P = 0.0009$). However, channel approach velocity was not a good predictor of secondary louver efficiency

TABLE. 4.— Grand secondary louver efficiency (see equation on page 6) of individuals successfully salvaged at the TFCF, Tracy, California, from March 1996 – November 1997. Order of fishes follows AFS (1991)

| Common Name | Scientific Name | Percent Successfully Louvered | n |
|---|---|---|---|
| Lamprey Species | *Petromyzontidae* | 72.7 | 11 |
| River lamprey | *Lampetra ayersi* | | |
| Pacific lamprey | *Lampetra tridentata* | | |
| White sturgeon | *Acipenser transmontanus* | 80.0 | 5 |
| American shad | *Alosa sapidissima* | 40.4 | 1,986 |
| Threadfin shad | *Dorosoma petenense* | 52.9 | 6,897 |
| Red shiner | *Cyprinella lutrensis* | 64.7 | 17 |
| Common carp | *Cyprinus carpio* | 32.8 | 58 |
| Golden shiner | *Notemigonus crysoleucas* | 75.0 | 28 |
| Sacramento blackfish | *Orthodon microlepidotus* | 88.2 | 17 |
| Splittail | *Pogonichthys macrolepidotus* | 71.2 | 765 |
| Sacramento sucker | *Catostomus occidentalis* | 32.2 | 839 |
| White catfish | *Ameiurus catus* | 86.5 | 2,516 |
| Black bullhead | *Ameiurus melas* | 80.0 | 5 |
| Brown bullhead | *Ameiurus nebulosus* | 92.3 | 26 |
| Channel catfish | *Ictalurus punctatus* | 73.4 | 576 |
| Wakasagi | *Hypomesus nipponensis* | 74.1 | 27 |
| Delta smelt | *Hypomesus transpacificus* | 65.0 | 1,112 |
| Longfin smelt | *Spirinchus thaleichthys* | 60.2 | 113 |
| Steelhead | *Oncorhynchus mykiss* | 100.0 | 22 |
| Chinook salmon | *Oncorhynchus tshawytscha* | 85.1 | 1,890 |
| Western mosquitofish | *Gambusia affinis* | 35.3 | 17 |
| Inland silverside | *Menidia beryllina* | 45.3 | 190 |
| Prickly sculpin | *Cottus asper* | 67.8 | 2,448 |
| Striped bass | *Morone saxatilis* | 61.5 | 4,017 |
| Warmouth | *Lepomis gulosus* | 76.8 | 56 |
| Bluegill | *Lepomis macrochirus* | 73.5 | 1,277 |
| Redear sunfish | *Lepomis microlophus* | 96.2 | 26 |
| Largemouth bass | *Micropterus salmoides* | 70.7 | 610 |
| Black crappie | *Pomoxis nigromaculatus* | 82.3 | 62 |
| Bigscale logperch | *Percina macrolepida* | 54.7 | 75 |
| Yellowfin goby | *Acanthogobius flavimanus* | 58.5 | 388 |
| Shimofuri goby | *Tridentiger bifasciatus* | 26.8 | 422 |
| Starry flounder | *Platichthys stellatus* | 90.5 | 21 |

TABLE 5.— Logistic regression analysis of the effects of three independent variables' on secondary louver efficiency at the TFCF, Tracy, California, from March 1996 – November 1997. Number of simultaneous 10-minute holding tank/sieve net samples were: splittail ($n$ = 121), delta smelt ($n$ = 149), chinook salmon ($n$ = 196), and striped bass ($n$ = 253)

| Model | Splittail Probability of Model Fit | Splittail Probability of Significance | Delta Smelt Probability of Model Fit | Delta Smelt Probability of Significance | Chinook Salmon Probability of Model Fit | Chinook Salmon Probability of Significance | Striped Bass Probability of Model Fit | Striped Bass Probability of Significance |
|---|---|---|---|---|---|---|---|---|
| Approach Velocity | 0.5375 | 0.5375 | 0.0028 | 0.0048 | 0.8639 | 0.8640 | 0.0420 | 0.0457 |
| Time of Day | 0.3312 | 0.3333 | 0.1414 | 0.1442 | 0.5137 | 0.5141 | 0.2570 | 0.2576 |
| Debris | 0.0379 | 0.0402 | 0.0025 | 0.0034 | 0.4523 | 0.4561 | 0.0007 | 0.0009 |
| Ap. Veloc.+ Time of Day | 0.5376 | 0.5856<br>0.3552 | 0.0034 | 0.0043<br>0.1235 | 0.7855 | 0.8127<br>0.5011 | 0.0358 | 0.0358<br>0.1901 |
| Ap. Veloc.+ Debris | 0.0830 | 0.4147<br>0.0343 | 0.0002 | 0.0061<br>0.0047 | 0.7536 | 0.0009<br>0.5279 | 0.0003 | 0.0380<br>0.0008 |
| Time of Day+ Debris | 0.0776 | 0.3728<br>0.0437 | 0.0081 | 0.4891<br>0.0078 | 0.5259 | 0.3967<br>0.3591 | 0.0024 | 0.4893<br>0.0014 |
| Ap. Veloc.+ Time of Day+ Debris | 0.1260 | 0.4351<br>0.3904<br>0.0368 | 0.0004 | 0.0060<br>0.4646<br>0.0118 | 0.7305 | 0.9239<br>0.3941<br>0.3721 | 0.0008 | 0.0326<br>0.3855<br>0.0013 |

(Somer's $D = 0.065$; $= 0.090$). For example, chinook salmon louver efficiency appears unrelated to channel approach velocity in some analyses (table 6). These conflicting results leave us without a consistent relationship between approach velocity and chinook salmon secondary louver efficiency.

For three other species of concern—splittail, threatened delta smelt, *Hypomesus transpacificus*, and striped bass—we analyzed statistically the influence of channel approach velocity, time of day, and debris loading on salvage efficiency. Only one (velocity) of these three independent variables influenced salvage efficiency for any species in a statistically significant manner (table 5). Yet, even when these factors were not statistically significant, we noted differences in salvage efficiency. Splittail louver efficiency was lower during crepuscular periods (table 7) and when debris load was light (table 8).

No statistically significant factor was isolated for delta smelt. However, on inspection of the empirical data, channel approach velocity appears inversely related to delta smelt louver efficiency (table 6). When channel approach velocity is less than 0.33 meter per second (m/s) (1.09 feet per second [ft/s]), delta smelt secondary louver efficiency is 82.5 percent. Secondary louver efficiency is 64.0 percent when channel approach velocities are between 0.33 and 0.95 m/s (1.09 and 3.1 f/s). Secondary louver efficiency is 13.0 percent when channel approach velocities exceed 0.95 m/s (3.1 ft/s).

Other factors also showed some relationship to delta smelt louver efficiency through inspections of the data. Delta smelt louver efficiency increased as debris in the 10-min counts increased (table 8). But delta smelt louver efficiency varied inversely with temperature (table 9).

Similarly to delta smelt, juvenile striped bass secondary louver efficiency was statistically not significantly influenced by approach velocity. However, table 6 shows that channel approach velocity appears inversely related to striped bass louver efficiency, and secondary louver efficiency is highest when channel approach velocity is less than 0.33 m/s (1.09 ft/s). Furthermore, striped bass efficiency increased with bypass ratio (table 10). But striped bass louver efficiency was independent of tidal state (table 11).

Secondary louver efficiency was low for some species of interest. Grand efficiency for American shad (*Alosa sapidissima*) was only 40.4 percent; in addition, efficiency was inversely proportional to temperature (table 9).

TABLE 6.—Secondary louver efficiency in three approach-velocity categories for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997

| Common Name | <0.33 m/s (<1.09 ft/s) Successfully Louvered (%) | <0.33m/s (1.09 ft/s) n | 0.33-0.95 m/s (1.09-3.1 ft/s) Successfully Louvered (%) | 0.33-0.95 m/s (1.09-3.1 ft/s) n | 0.95 m/s (>3.1 ft/s) Successfully Louvered (%) | 0.95 m/s ( 3.1 ft/s) n |
|---|---|---|---|---|---|---|
| American shad | — | 0 | 39.4 | 1,614 | 44.9 | 372 |
| Bigscale logperch | 100.0 | 3 | 53.5 | 71 | — | 1 |
| Black bullhead | — | 0 | 80.0 | 5 | — | 0 |
| Black crappie | 100.0 | 1 | 81.5 | 54 | 85.7 | 7 |
| Bluegill | 47.7 | 44 | 74.6 | 949 | 73.9 | 284 |
| Brown bullhead | 100.0 | 1 | 95.8 | 24 | — | 1 |
| Centrarchids | — | 0 | 37.5 | 8 | — | 1 |
| Channel catfish | 66.7 | 3 | 71.1 | 523 | 94.0 | 50 |
| Chinook salmon | 85.7 | 14 | 84.8 | 1,686 | 87.4 | 190 |
| Common carp | — | 0 | 32.8 | 58 | — | 0 |
| Delta smelt | 82.5 | 103 | 64.0 | 986 | 13.0 | 23 |
| Golder shiner | — | 0 | 74.1 | 27 | 100.0 | 1 |
| Goldfish | — | 0 | 100.0 | 2 | — | 0 |
| Green sturgeon | — | 0 | — | 1 | — | 0 |
| Green sunfish | — | 0 | 100.0 | 1 | — | 0 |
| Inland silverside | 33.3 | 3 | 43.5 | 168 | 63.2 | 19 |
| Lamprey Species | — | 0 | 80.0 | 10 | — | 1 |
| Largemouth bass | 100.0 | 7 | 69.9 | 582 | 71.4 | 21 |
| Longfin smelt | 53.8 | 13 | 60.6 | 99 | 100.0 | 1 |
| Prickly sculpin | 91.2 | 171 | 66.8 | 2,136 | 53.2 | 141 |
| Pumpkinseed | — | 0 | 100.0 | 1 | — | 0 |
| Red shiner | — | 0 | 68.8 | 16 | — | 1 |
| Redear sunfish | 100.0 | 2 | 94.7 | 19 | 100.0 | 5 |
| Sacramento blackfish | — | 0 | 88.2 | 17 | — | 0 |
| Sacramento sucker | — | 4 | 30.7 | 807 | 53.6 | 28 |
| Shimofuri goby | 100.0 | 1 | 26.7 | 420 | — | 1 |
| Splittail | — | 0 | 71.1 | 751 | 64.3 | 14 |
| Starry flounder | — | 0 | 90.0 | 20 | 100.0 | 1 |
| Steelhead | — | 0 | 100.0 | 20 | 100.0 | 2 |
| Striped bass | 96.7 | 120 | 59.3 | 3,756 | 65.2 | 141 |
| Threadfin shad | 58.0 | 143 | 50.8 | 5,632 | 61.7 | 1122 |
| Threespine stickleback | — | 0 | 66.7 | 3 | — | 0 |
| Tule perch | — | 0 | 100.0 | 2 | — | 0 |
| Wakasagi | — | 0 | 73.1 | 26 | 100.0 | 1 |
| Warmouth | 100.0 | 1 | 81.0 | 42 | 61.5 | 13 |
| Western mosquitofish | — | 0 | 35.7 | 14 | 33.3 | 3 |
| White catfish | 98.1 | 53 | 86.3 | 2,155 | 83.1 | 308 |
| White crappie | — | 0 | 100.0 | 1 | — | 0 |
| White sturgeon | — | 0 | 80.0 | 5 | — | 0 |
| Yellowfin goby | 100.0 | 1 | 57.7 | 381 | 100.0 | 6 |

TABLE 7.— Secondary louver efficiency at three periods of day for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997. Crepuscular period data combine dawn and dusk samples

| Common Name | Day Successfully Louvered (%) | Day n | Crepuscular Successfully Louvered (%) | Crepuscular n | Night Successfully Louvered (%) | Night n |
|---|---|---|---|---|---|---|
| Lamprey Species | 100.0 | 3 | 100.0 | 1 | 57.1 | 7 |
| River lamprey | | | | | | |
| Pacific lamprey | | | | | | |
| White sturgeon | 50.0 | 2 | 100.0 | 1 | 100.0 | 2 |
| American shad | 37.4 | 1,099 | 35.5 | 414 | 51.8 | 473 |
| Threadfin shad | 42.8 | 2,935 | 49.9 | 889 | 63.4 | 3,073 |
| Red shiner | 83.3 | 6 | 0.0 | 1 | 60.0 | 10 |
| Common carp | 17.4 | 23 | 34.8 | 23 | 58.3 | 12 |
| Golden shiner | 63.6 | 11 | 100.0 | 4 | 76.9 | 13 |
| Sacramento blackfish | 87.5 | 8 | 75.0 | 4 | 100.0 | 5 |
| Splittail | 74.6 | 319 | 59.9 | 172 | 74.5 | 274 |
| Sacramento sucker | 37.6 | 189 | 23.7 | 266 | 35.4 | 384 |
| White catfish | 87.9 | 495 | 86.9 | 444 | 86.0 | 1,577 |
| Black bullhead | 100.0 | 1 | 100.0 | 1 | 66.7 | 3 |
| Brown bullhead | 100.0 | 3 | 100.0 | 3 | 90.0 | 20 |
| Channel catfish | 61.0 | 182 | 84.8 | 66 | 78.0 | 328 |
| Wakasagi | 81.8 | 11 | 75.0 | 8 | 62.5 | 8 |
| Delta smelt | 65.7 | 720 | 60.6 | 188 | 66.7 | 204 |
| Longfin smelt | 62.1 | 66 | 52.9 | 34 | 69.2 | 13 |
| Steelhead | 100.0 | 8 | 100.0 | 7 | 100.0 | 7 |
| Chinook salmon | 82.9 | 346 | 84.3 | 408 | 86.0 | 1,136 |
| Western mosquitofish | 25.0 | 4 | 33.3 | 3 | 40.0 | 10 |
| Inland silverside | 36.5 | 96 | 66.7 | 9 | 52.9 | 85 |
| Prickly sculpin | 72.4 | 1,410 | 57.1 | 524 | 66.0 | 514 |
| Striped bass | 62.2 | 2,434 | 60.8 | 431 | 60.1 | 1,152 |
| Warmouth | 100.0 | 2 | 100.0 | 4 | 74.0 | 50 |
| Bluegill | 72.1 | 308 | 77.0 | 183 | 73.3 | 786 |
| Redear sunfish | 100.0 | 15 | 100.0 | 4 | 85.7 | 7 |
| Largemouth bass | 74.6 | 240 | 63.9 | 61 | 68.9 | 309 |
| Black crappie | 87.1 | 31 | 81.3 | 16 | 73.3 | 15 |
| Bigscale logperch | 56.8 | 44 | 42.9 | 14 | 58.8 | 17 |
| Yellowfin goby | 83.3 | 66 | 57.9 | 19 | 53.1 | 303 |
| Shimofuri goby | 21.8 | 335 | 41.7 | 12 | 46.7 | 75 |
| Starry flounder | 100.0 | 8 | — | 0 | 84.6 | 13 |

TABLE 8.— Secondary louver efficiency at three debris levels for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997. Debris mass was obtained in the holding tank during a 10-min simultaneous holding tank/sieve net sample

| Common Name | < 350 g (< 12.3 oz) Successfully Louvered (%) | < 350 g (< 12.3 oz) n | 350 – 1000 g (12.3 – 35.3 oz) Successfully Louvered (%) | 350 – 1000 g (12.3 – 35.3 oz) n | 1000 g ( 35.3 oz) Successfully Louvered (%) | 1000 g ( 35.3 oz) n |
|---|---|---|---|---|---|---|
| Lamprey Species | 100.0 | 1 | — | 0 | 70.0 | 10 |
| River lamprey | | | | | | |
| Pacific lamprey | | | | | | |
| White sturgeon | 50.0 | 2 | 100.0 | 1 | 100.0 | 1 |
| American shad | 37.4 | 511 | 28.6 | 825 | 57.8 | 650 |
| Threadfin shad | 40.4 | 2,264 | 46.9 | 2,080 | 69.4 | 2,421 |
| Red shiner | 57.1 | 7 | 33.3 | 3 | 80.0 | 5 |
| Common carp | 16.3 | 43 | 100.0 | 7 | 100.0 | 3 |
| Golden shiner | 62.5 | 8 | 62.5 | 8 | 91.7 | 12 |
| Sacramento blackfish | 100.0 | 2 | 75.0 | 4 | 90.9 | 11 |
| Splittail | 57.3 | 248 | 78.7 | 235 | 83.7 | 257 |
| Sacramento sucker | 18.6 | 601 | 70.2 | 141 | 61.8 | 89 |
| White catfish | 76.0 | 434 | 84.8 | 580 | 90.4 | 1,442 |
| Black bullhead | — | 0 | 50.0 | 2 | 100.0 | 3 |
| Brown bullhead | 100.0 | 1 | 100.0 | 5 | 90.0 | 20 |
| Channel catfish | 53.8 | 221 | 82.2 | 107 | 87.6 | 242 |
| Wakasagi | 68.4 | 19 | 66.7 | 3 | 100.0 | 5 |
| Delta smelt | 55.2 | 717 | 85.2 | 305 | 91.5 | 71 |
| Longfin smelt | 51.6 | 91 | 92.3 | 13 | 100.0 | 9 |
| Steelhead | 100.0 | 4 | 100.0 | 5 | 100.0 | 11 |
| Chinook salmon | 77.8 | 334 | 79.5 | 347 | 89.0 | 1,125 |
| Western mosquitofish | 60.0 | 5 | 25.0 | 4 | 14.3 | 7 |
| Inland silverside | 37.5 | 56 | 30.2 | 53 | 62.8 | 78 |
| Prickly sculpin | 67.1 | 1,469 | 70.7 | 569 | 66.8 | 373 |
| Striped bass | 51.4 | 2,198 | 72.9 | 1,089 | 79.4 | 683 |
| Warmouth | 50.0 | 8 | 60.0 | 5 | 83.7 | 43 |
| Bluegill | 54.5 | 112 | 63.0 | 238 | 77.5 | 874 |
| Redear sunfish | 100.0 | 10 | 100.0 | 6 | 90.0 | 10 |
| Largemouth bass | 55.9 | 281 | 77.3 | 176 | 92.6 | 148 |
| Black crappie | 53.8 | 13 | 73.3 | 15 | 96.9 | 32 |
| Bigscale logperch | 47.8 | 46 | 66.7 | 21 | 62.5 | 8 |

TABLE 9.—Secondary louver efficiency at three temperature ranges for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997

| Common Name | < 14 °C (< 57.2 °F) Successfully Louvered (%) | < 14 °C (< 57.2 °F) n | 14 – 20 °C (57.2 – 68 °F) Successfully Louvered (%) | 14 – 20 °C (57.2 – 68 °F) n | 20 °C ( 68 °F) Successfully Louvered (%) | 20 °C ( 68 °F) n |
|---|---|---|---|---|---|---|
| Lamprey Species | 75.0 | 4 | 71.4 | 7 | — | 0 |
| Pacific lamprey | | | | | | |
| River lamprey | | | | | | |
| White sturgeon | 100.0 | 1 | 75.0 | 4 | — | 0 |
| American shad | 45.5 | 237 | 40.7 | 970 | 38.5 | 779 |
| Threadfin shad | 59.4 | 957 | 59.2 | 2,832 | 45.1 | 3,108 |
| Red shiner | 25.0 | 4 | 75.0 | 8 | 80.0 | 5 |
| Common carp | 12.5 | 8 | 30.5 | 36 | 50.0 | 14 |
| Golden shiner | 75.0 | 4 | 92.8 | 14 | 50.0 | 10 |
| Sacramento blackfish | 100.0 | 2 | 90.0 | 10 | 80.0 | 5 |
| Splittail | 80.0 | 75 | 71.6 | 381 | 68.8 | 309 |
| Sacramento sucker | 41.3 | 29 | 31.1 | 751 | 40.6 | 59 |
| White catfish | 86.2 | 313 | 86.5 | 1,655 | 86.6 | 548 |
| Black bullhead | 100.0 | 1 | 66.6 | 3 | 100.0 | 1 |
| Brown bullhead | 100.0 | 6 | 86.6 | 15 | 100.0 | 5 |
| Channel catfish | — | 0 | 25.0 | 4 | 40.0 | 5 |
| Wakasagi | 0.0 | 1 | 82.3 | 17 | 66.6 | 9 |
| Delta smelt | 78.0 | 146 | 65.4 | 588 | 59.2 | 378 |
| Longfin smelt | 83.3 | 12 | 57.9 | 88 | 53.8 | 13 |
| Steelhead | 100.0 | 3 | 100.0 | 17 | 100.0 | 2 |
| Chinook salmon | 87.7 | 49 | 85.5 | 1,576 | 81.8 | 265 |
| Western mosquitofish | 66.6 | 3 | 20.0 | 5 | 33.3 | 9 |
| Inland silverside | 50.0 | 16 | 61.5 | 78 | 31.2 | 96 |
| Prickly sculpin | 78.9 | 176 | 65.7 | 1,889 | 72.5 | 383 |
| Striped bass | 63.9 | 441 | 67.6 | 726 | 59.5 | 2,850 |
| Warmouth | 70.0 | 30 | 100.0 | 18 | 50.0 | 8 |
| Bluegill | 69.3 | 323 | 74.4 | 806 | 77.7 | 148 |
| Redear sunfish | 100.0 | 2 | 92.3 | 13 | 100.0 | 11 |
| Largemouth bass | 72.1 | 61 | 80.3 | 102 | 68.2 | 447 |
| Black crappie | 100.0 | 3 | 86.6 | 45 | 64.2 | 14 |
| Bigscale logperch | 83.3 | 6 | 51.1 | 43 | 53.8 | 26 |
| Yellowfin goby | 55.0 | 69 | 64.2 | 98 | 57.0 | 221 |
| Shimofuri goby | 39.3 | 94 | 57.1 | 21 | 20.8 | 307 |
| Starry flounder | 90.0 | 10 | 100.0 | 1 | 90.0 | 10 |

TABLE 10.—Secondary louver efficiency in three bypass ratio categories for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997

| Common Name | < 1.2 Successfully Louvered (%) | < 1.2 n | 1.2 – 1.6 Successfully Louvered (%) | 1.2 – 1.6 n | 1.6 Successfully Louvered (%) | 1.6 n |
|---|---|---|---|---|---|---|
| Lamprey Species | 75.0 | 800 | 50.0 | 200 | — | 0 |
| River lamprey | | | | | | |
| Pacific lamprey | | | | | | |
| White sturgeon | 50.0 | 2 | 100.0 | 200 | — | 0 |
| American shad | 40.8 | 867 | 41.3 | 673 | 43.7 | 183 |
| Threadfin shad | 54.1 | 2,813 | 52.4 | 2,342 | 42.6 | 514 |
| Red shiner | 60.0 | 5 | 83.3 | 6 | 50.0 | 2 |
| Common carp | 6.7 | 6 | 35.7 | 14 | 85.7 | 7 |
| Golden shiner | 69.2 | 13 | 70.0 | 10 | 100.0 | 3 |
| Sacramento blackfish | 100.0 | 4 | 100.0 | 6 | 50.0 | 2 |
| Splittail | 75.1 | 133 | 73.5 | 310 | 73.8 | 88 |
| Sacramento sucker | 62.2 | 45 | 32.3 | 229 | 58.3 | 48 |
| White catfish | 88.2 | 1,166 | 82.9 | 705 | 85.3 | 123 |
| Brown bullhead | 88.8 | 18 | 100.0 | 3 | 100.0 | 3 |
| Channel catfish | 83.5 | 184 | 65.7 | 286 | 60.0 | 33 |
| Wakasagi | 50.0 | 2 | 75.0 | 4 | 77.7 | 9 |
| Delta smelt | 70.7 | 263 | 58.0 | 205 | 71.3 | 381 |
| Longfin smelt | 47.0 | 34 | 61.1 | 18 | 75.0 | 44 |
| Steelhead | 100.0 | 11 | 100.0 | 3 | — | 0 |
| Chinook salmon | 85.2 | 987 | 88.5 | 453 | 84.6 | 117 |
| Western mosquitofish | 25.0 | 8 | 66.6 | 3 | — | 0 |
| Inland silverside | 45.0 | 71 | 55.5 | 54 | 25.0 | 24 |
| Prickly sculpin | 65.8 | 369 | 70.1 | 463 | 77.4 | 655 |
| Striped bass | 58.4 | 1,046 | 60.5 | 1,652 | 67.6 | 650 |
| Warmouth | 71.0 | 38 | 90.0 | 10 | 100.0 | 1 |
| Bluegill | 73.4 | 792 | 78.7 | 320 | 64.4 | 76 |
| Redear sunfish | 85.7 | 7 | 100.0 | 7 | 100.0 | 3 |
| Largemouth bass | 76.8 | 138 | 66.8 | 326 | 80.3 | 61 |
| Black crappie | 80.9 | 21 | 91.3 | 23 | 50.0 | 8 |
| Bigscale logperch | 28.5 | 7 | 65.5 | 29 | 75.0 | 12 |
| Yellowfin goby | 46.6 | 60 | 55.1 | 234 | 85.2 | 34 |
| Shimofuri goby | 13.3 | 127 | 33.9 | 206 | 5.7 | 52 |
| Starry flounder | 83.3 | 6 | 90.9 | 11 | 100.0 | 4 |

TABLE 11.—Secondary louver efficiency at three tidal states for fish collected at the TFCF, Tracy, California, from March 1996 – September 1997. Slack tide is the 6-h period between sequential tidal peaks

| Common Name | Out Successfully Louvered (%) | Out n | Slack Successfully Louvered (%) | Slack n | In Successfully Louvered (%) | In n |
|---|---|---|---|---|---|---|
| Lamprey Species | 33.3 | 3 | 100.0 | 1 | 85.7 | 7 |
| River lamprey | | | | | | |
| Pacific lamprey | | | | | | |
| White sturgeon | 100.0 | 2 | — | 0 | 66.7 | 3 |
| American shad | 41.7 | 770 | 37.0 | 608 | 42.3 | 608 |
| Threadfin shad | 54.1 | 2,465 | 46.2 | 1,947 | 57.0 | 2,485 |
| Red shiner | 72.7 | 11 | — | 1 | 60.0 | 5 |
| Common carp | 47.4 | 19 | 20.0 | 15 | 29.2 | 24 |
| Golden shiner | 80.0 | 5 | 71.4 | 7 | 75.0 | 16 |
| Sacramento blackfish | 66.7 | 6 | 100.0 | 5 | 100.0 | 6 |
| Splittail | 70.1 | 214 | 70.0 | 247 | 73.0 | 304 |
| Sacramento sucker | 34.5 | 278 | 33.9 | 224 | 29.1 | 337 |
| White catfish | 83.4 | 945 | 84.1 | 473 | 90.3 | 1,098 |
| Black bullhead | 66.7 | 3 | — | 0 | 100.0 | 2 |
| Brown bullhead | 85.7 | 7 | 100.0 | 7 | 91.7 | 12 |
| Channel catfish | 69.9 | 269 | 63.6 | 110 | 83.8 | 197 |
| Wakasagi | 70.0 | 10 | 100.0 | 1 | 75.0 | 16 |
| Delta smelt | 62.0 | 368 | 62.1 | 240 | 68.7 | 504 |
| Longfin smelt | 51.1 | 45 | 61.3 | 31 | 70.3 | 37 |
| Steelhead | 100.0 | 6 | 100.0 | 1 | 100.0 | 15 |
| Chinook salmon | 85.8 | 494 | 76.3 | 270 | 86.9 | 1126 |
| Western mosquitofish | 25.0 | 8 | 100.0 | 4 | 0.0 | 5 |
| Inland silverside | 37.8 | 74 | 25.9 | 27 | 57.3 | 89 |
| Prickly sculpin | 69.6 | 1,165 | 58.0 | 531 | 71.8 | 752 |
| Striped bass | 60.6 | 1,448 | 62.7 | 1,008 | 61.5 | 1,561 |
| Warmouth | 76.9 | 26 | 54.5 | 11 | 89.5 | 19 |
| Bluegill | 78.2 | 655 | 61.5 | 195 | 71.9 | 427 |
| Redear sunfish | 92.3 | 13 | 100.0 | 4 | 100.0 | 9 |
| Largemouth bass | 69.7 | 188 | 71.8 | 216 | 70.4 | 206 |
| Black crappie | 76.9 | 26 | 93.3 | 15 | 81.0 | 21 |
| Bigscale logperch | 57.1 | 28 | 45.0 | 20 | 59.3 | 27 |
| Yellowfin goby | 77.2 | 57 | 63.8 | 105 | 51.3 | 226 |
| Shimofuri goby | 26.9 | 186 | 24.7 | 93 | 28.0 | 143 |
| Starry flounder | 92.3 | 13 | 100.0 | 1 | 85.7 | 7 |

Furthermore, the efficiency for American shad is lower during daytime (table 7: 37.4 percent) and crepuscular (dawn and dusk combined) periods (35.5 percent) than at night (51.8 percent). Threadfin shad, *Dorosoma petenense*, showed a similar trend with the highest secondary efficiency observed at night (63.4 percent) and lower efficiencies observed during the day (42.8 percent) and crepuscular periods (49.9 percent).

As expected, for most species, secondary louver efficiency did not consistently vary with tidal state (table 11). The absolute number of fish entrained to the TFCF might vary with an incoming tide, but we did not expect this to vary the efficiency with which the louvers operate.

Similar to tidal state, we did not expect secondary efficiency to vary with the weight of debris obtained in a 10-min holding tank count (table 8). But 25 of the 32 species showed an increase in louver efficiency with an increasing debris load. We do not know if debris load was directly correlated with fouling of the louvers by debris. For example, when we measured extremely high debris loads (greater than 1,000 g in the 10-min holding tank count), the louvers could be dirty or clean depending on the time since they were last cleaned. It is possible that increased debris load in the 10-min sample is associated with higher debris fouling on the louvers; this fouling might reduce the area through which fish might pass from the secondary louvers, allowing an increase in efficiency. Splittail was 1 of 25 species that displayed this trend: higher debris loads provided higher secondary louver efficiency. Because debris load may not be related to fouling, we decided to further investigate the relationship between debris and louver efficiency using splittail as an example.

Secondary louver efficiency data for almost all species were not distributed normally (figures 4-8). Most commonly, these data were bimodal; no known transformation will provide normally distributed data from such distributions. Data for splittail were not distributed normally (figure 4d). We hypothesized this was due to the common occurrence of only one fish coming through the secondary channel at a time. Therefore, we decided to inject a number of splittail (n=40) to produce data distributed normally (figure 9) and allow us to employ parametric statistical techniques to elucidate the relationship between time of day, debris fouling, and splittail secondary louver efficiency.

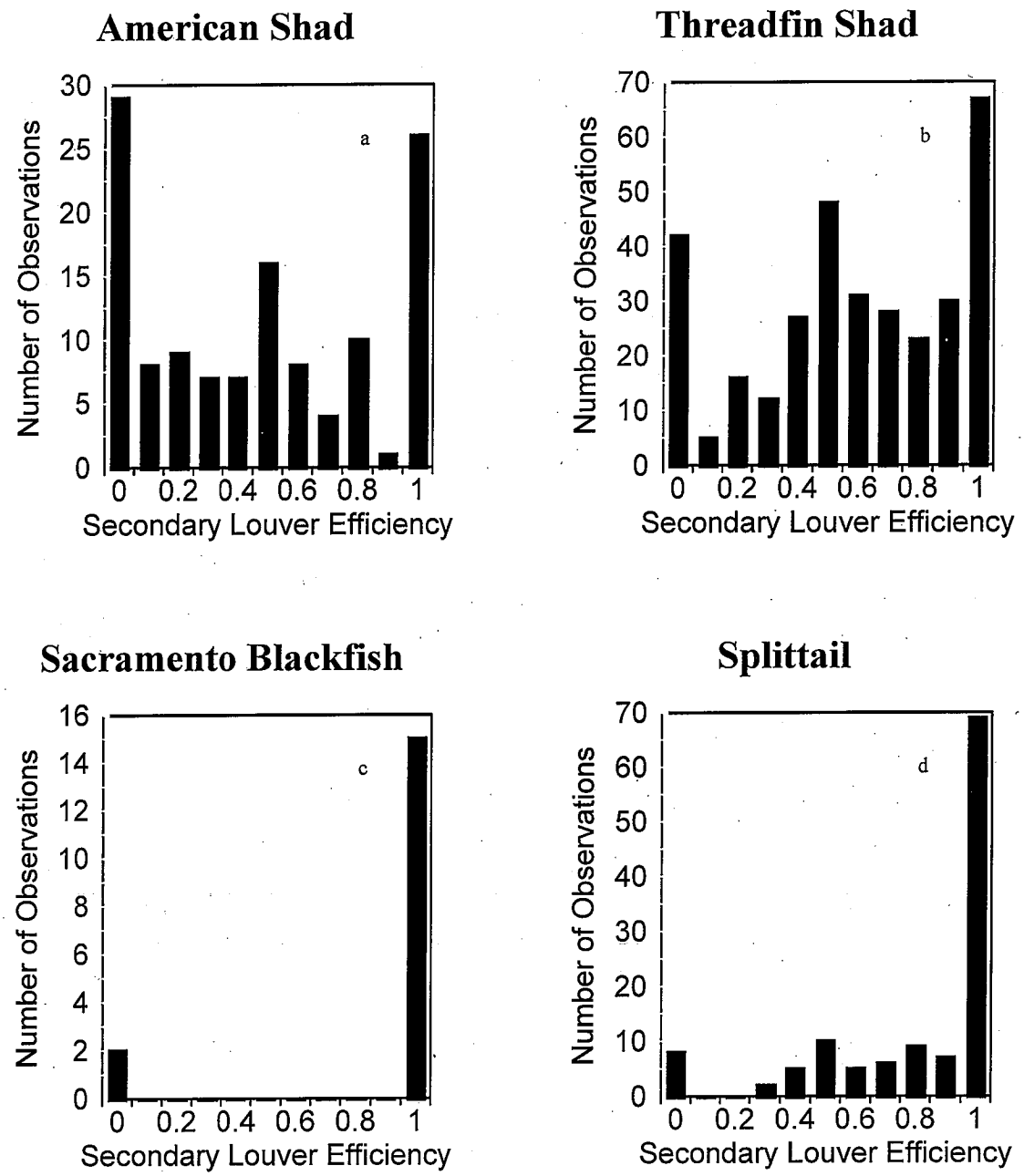



FIGURE 4.— Frequency distribution of secondary louver efficiency observations for (a) American shad, (b) threadfin shad, (c) Sacramento blackfish, and (d) splittail at the TFCF, March 1996 – November 1997.

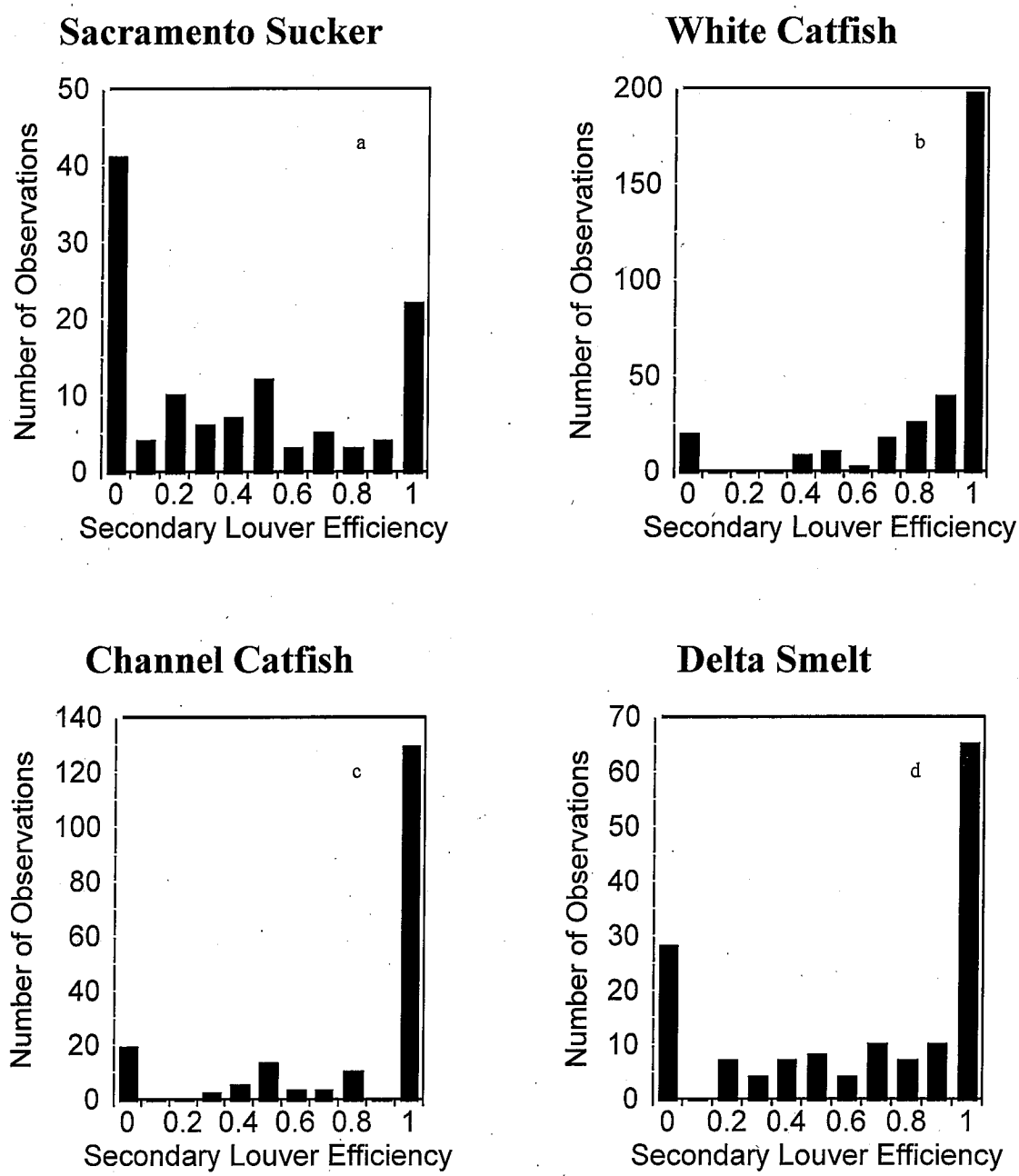



FIGURE 5.— Frequency distribution of secondary louver efficiency observations for (a) Sacramento sucker, (b) white catfish, (c) channel catfish, and (d) delta smelt at the TFCF, March 1996 – November 1997.

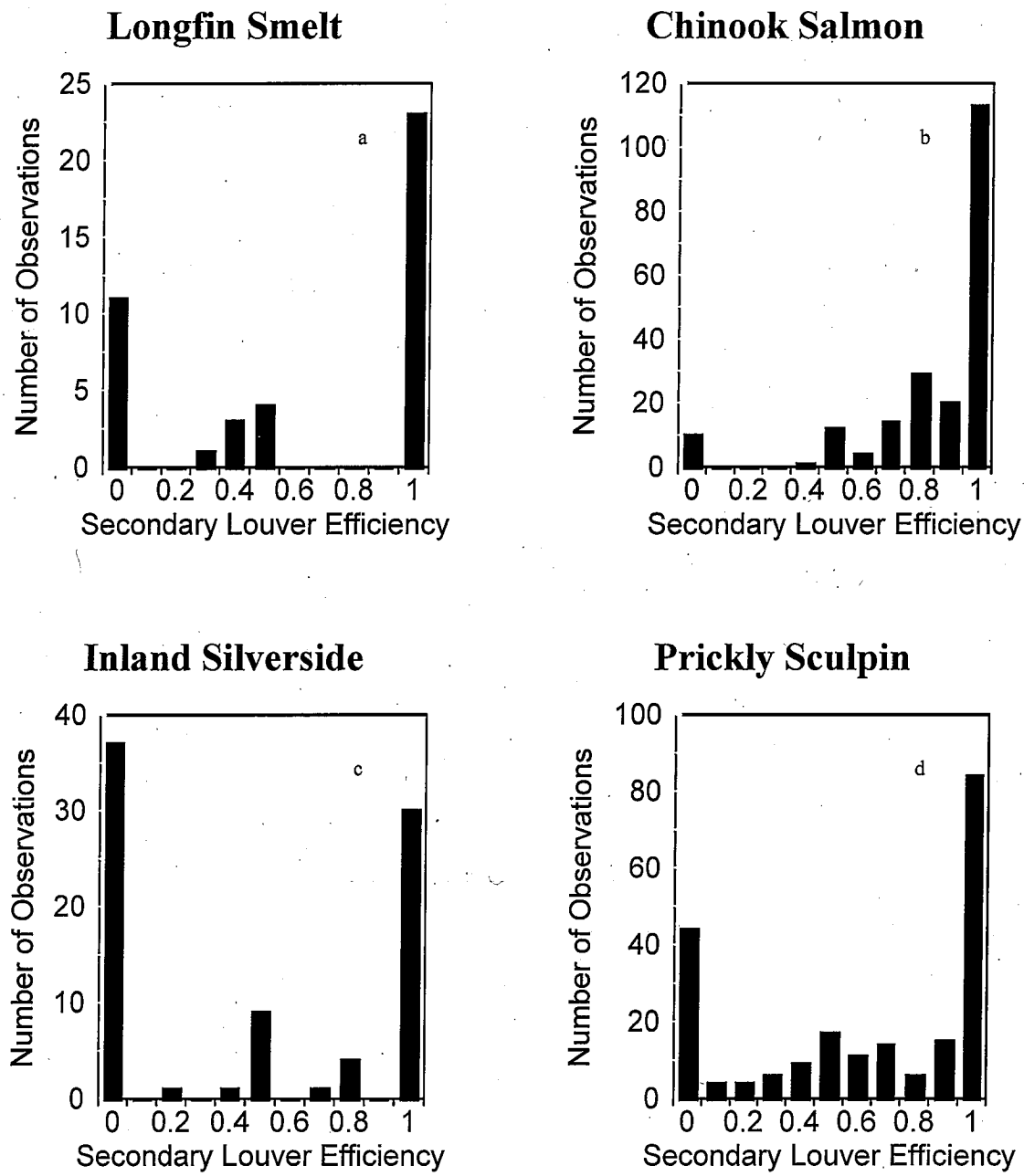



FIGURE 6.— Frequency distribution of secondary louver efficiency observations for (a) longfin smelt, (b) chinook salmon, (c) inland silverside, and (d) prickly sculpin at the TFCF, March 1996 – November 1997.

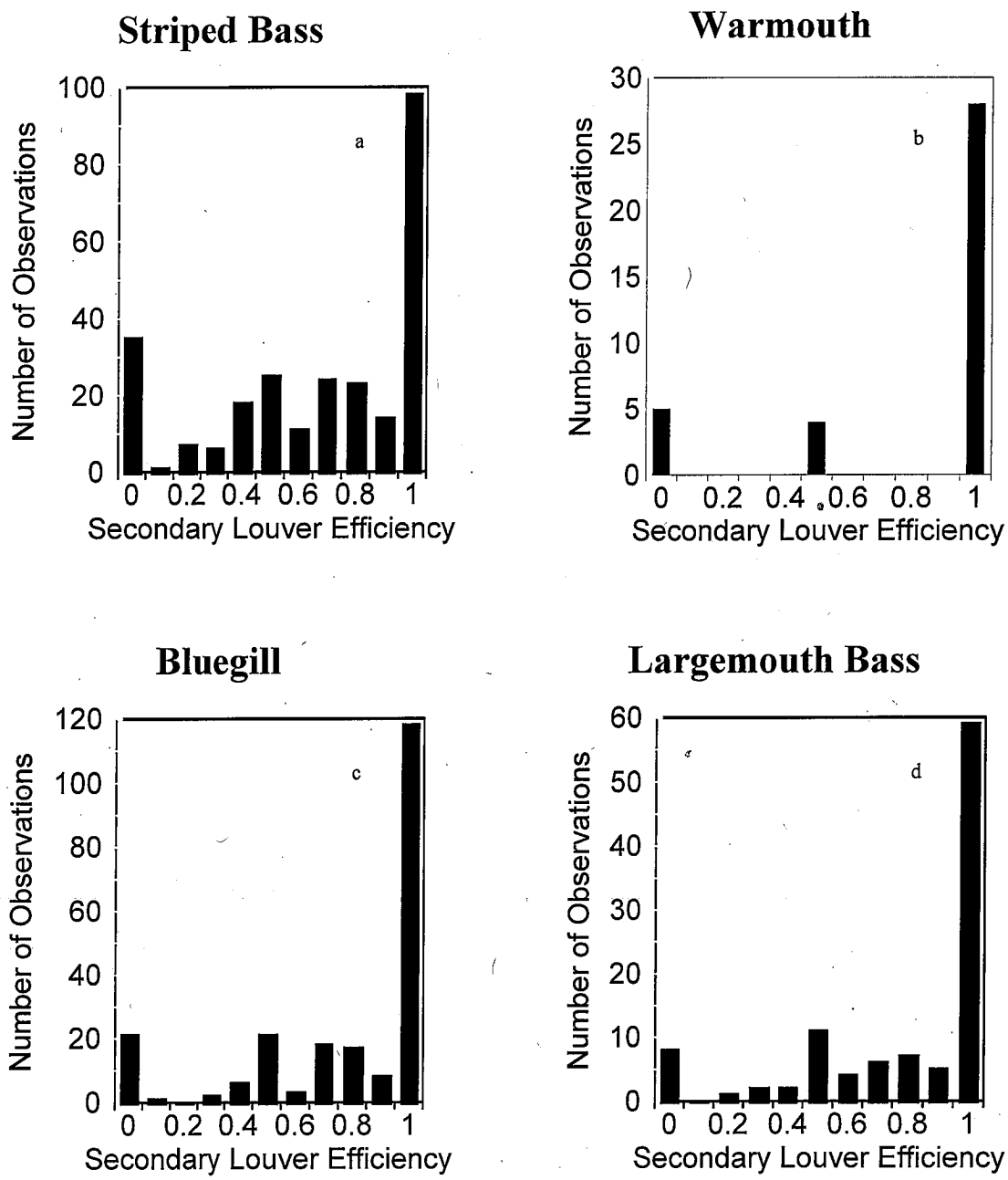



FIGURE 7.— Frequency distribution of secondary louver efficiency observations for (a) striped bass, (b) warmouth, (c) bluegill, and (d) largemouth bass at the TFCF, March 1996 – November 1997.

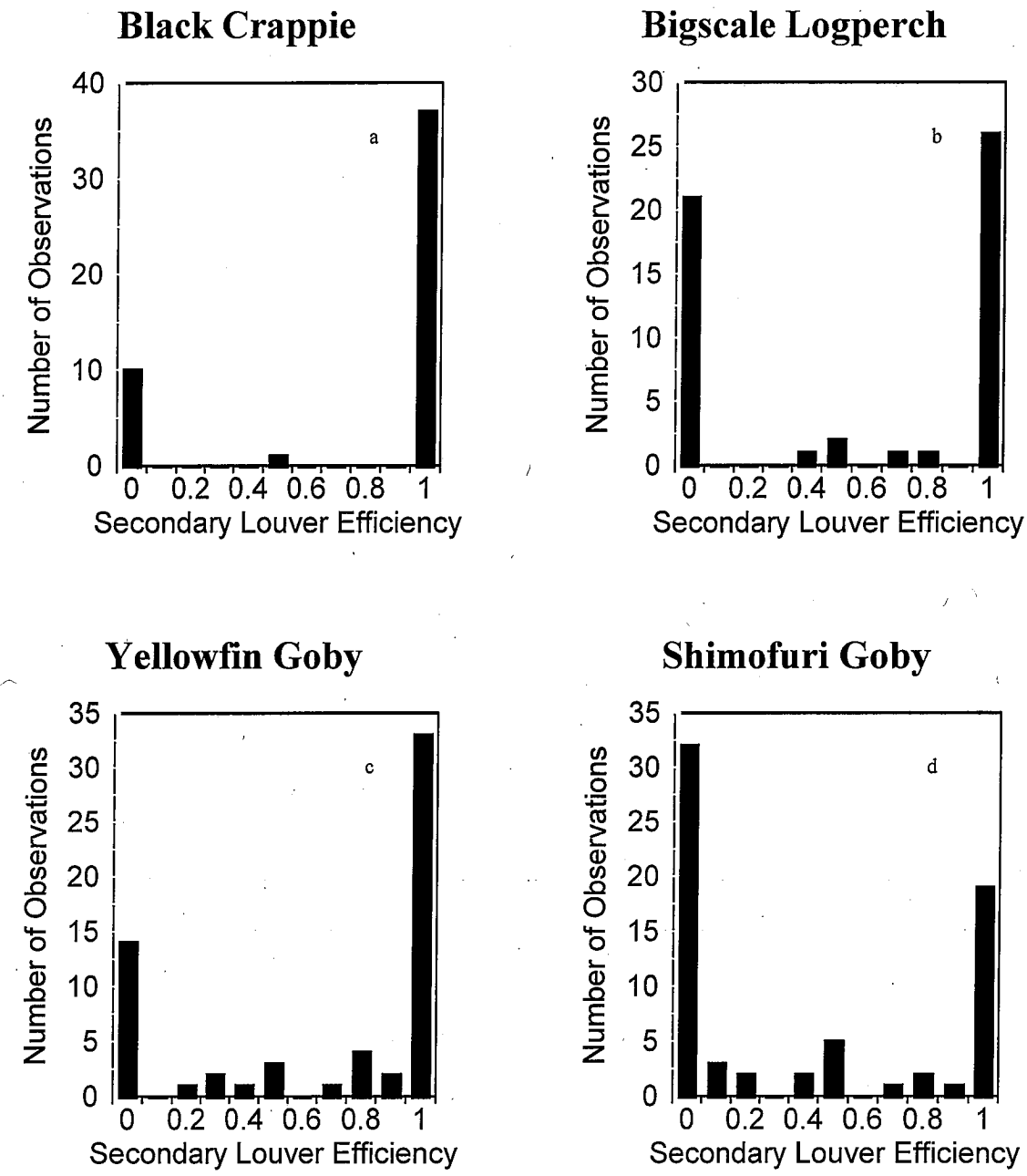



FIGURE 8.— Frequency distribution of secondary louver efficiency observations for (a) black crappie, (b) bigscale logperch, (c) yellowfin goby, and (d) shimofuri goby at the TFCF, March 1996 – November 1997.

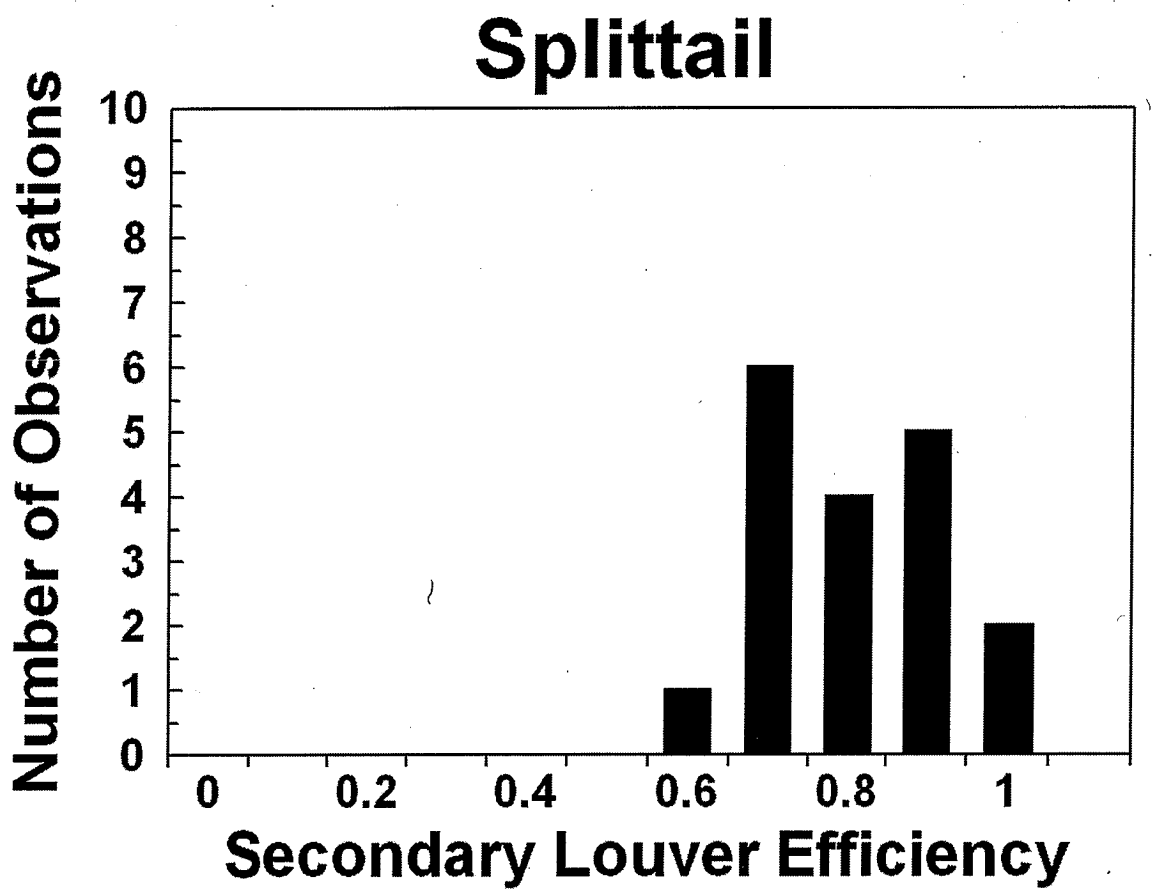



FIGURE 9.—Distribution of splittail secondary louver efficiency during injection experiments.

Splittail louver efficiency was also assessed through an experimental approach (table 12). Velocity profiles conducted without a net (figure 10a), with the control net (figure 10b), and with the experimental vegetation net (figure 10c) showed the experimental net was influencing the velocity profile in the secondary channel.

When isolated through experimentation, time of day exhibits a statistically significant impact on splittail salvage efficiency ($F = 9.92$; $P = 0.00071$). For the specific set of conditions under which the experiments were conducted, mean splittail louver efficiency during the day was 81.2 percent and at night it was 67.9 percent. Debris fouling simulated by the experimental net significantly reduced splittail secondary louver efficiency during the day (table 12).

TABLE 12.— Net experimental louver efficiency for splittail released in the secondary channel at the TFCF, March 1999 – May 1999. Superscripts indicate statistically significant difference via Two-Way, Model I ANOVA and planned comparison of means

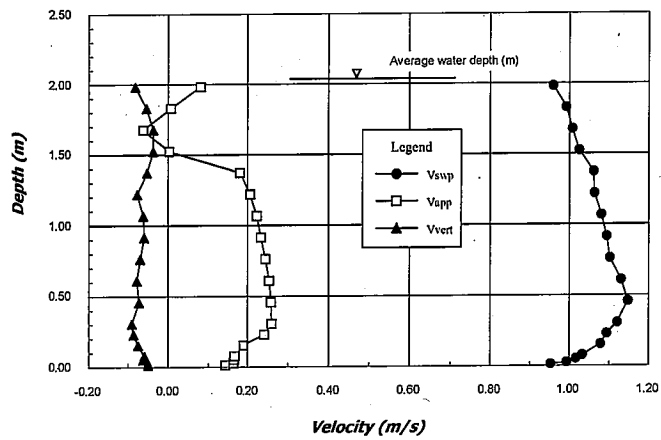
| Treatment | Louver Efficiency, Day | sd | Louver Efficiency, Night | sd |
|---|---|---|---|---|
| Controls | 86.5[a] | 7.6 | 68.8[c] | 8.4 |
| Vegetation net | 73.2[b] | 9.2 | 66.5[c] | 6 |

We estimated the amount of time spent collecting the empirical data to be 1,870 human-hours or 233 days. Next, we calculated the time spent obtaining the experimental observations concerning the influence of time of day and debris loading on splittail louver efficiency: 360 human-hours or 45 days. The empirical approach yielded one statistically significant relationship: channel approach velocity influences chinook salmon louver efficiency. The experimental approach yielded two statistically significant relationships: time of day and debris load influence splittail louver efficiency. Therefore, we suggest the experimental approach may be more efficient at demonstrating statistically significant influences on louver efficiency for particular species. However, the empirical approach allows the assessment of many factors (table 2) and their potential influence on louver efficiency for all fish species caught at the TFCF.

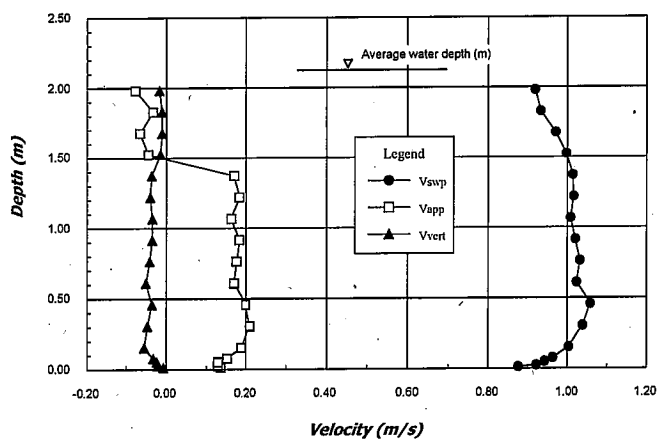
## Delta Smelt Recommendation

After conducting the Probit analysis and inspecting the data, it seems possible to achieve better than 75 percent secondary louver efficiency for delta smelt.

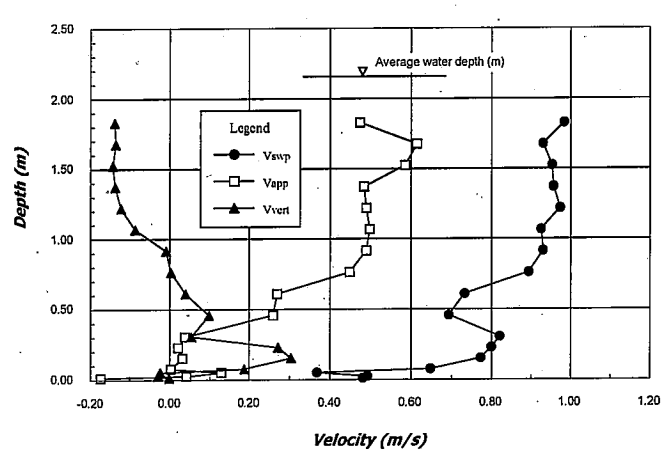
We plotted the predicted lower limit vs. louver efficiency (figure 11). With this graph in mind, we recommend using an average channel approach velocity of 0.33 m/s (1.09 ft/s) when the principal objective is to salvage delta smelt. The lower limit figure (figure 11) predicts that we should achieve approximately 80 percent secondary louver efficiency with this value. We would recommend an even lower channel velocity, but it seems unlikely to us that we can keep louver efficiency for other fish if approach velocity is




(a) No net




(b) Control net




(c) Experimental debris net

FIGURE 10.— Three dimensional velocity profile in front of the anterior louver array with (a) no net, (b) the control net, and (c) the experimental debris net in place. The velocity probe was placed 5.1 cm (2 in) from the louver array surface.

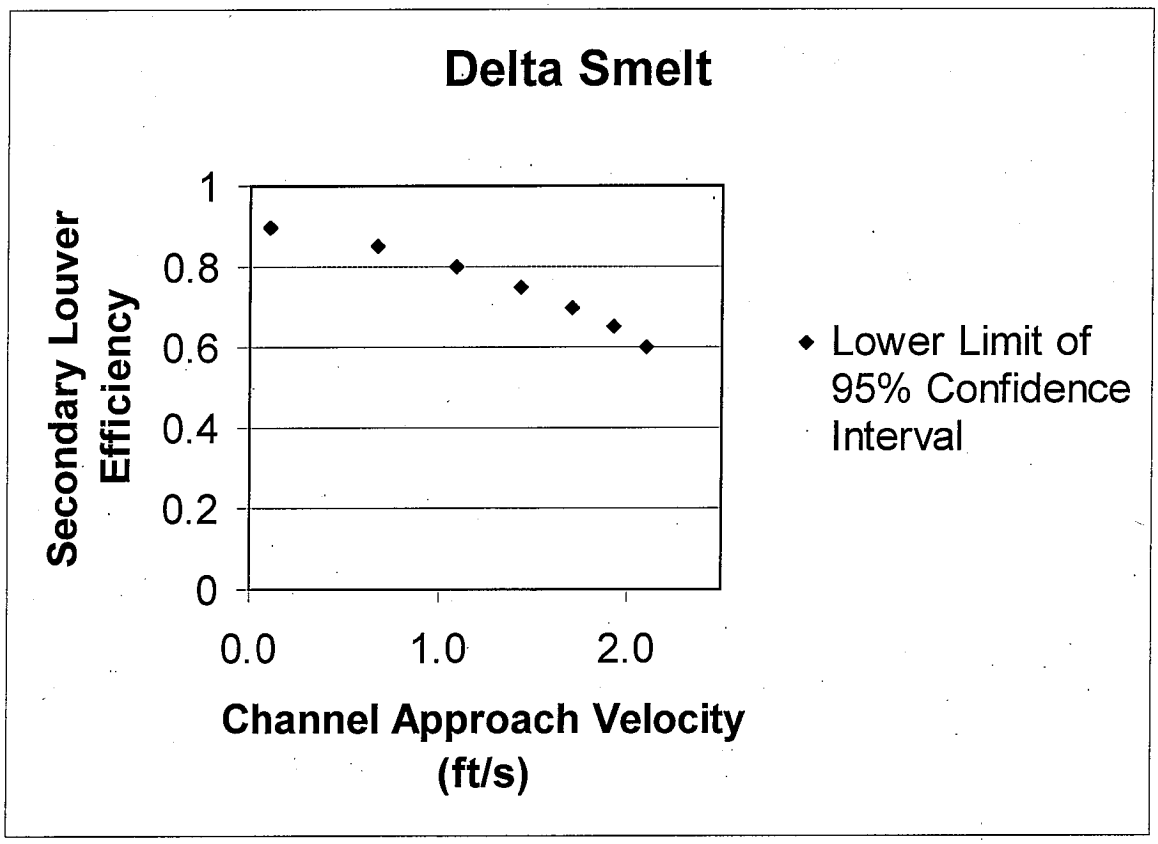



FIGURE 11.— Predicted secondary louver efficiency for delta smelt given channel approach velocity. These predictions were made using Probit analysis to generate the mean and confidence limits predicted at a particular channel velocity. (See page 9.)

lower than 0.33 m/s (1.09 ft/s). Thus, this recommendation may allow us to get above 75 percent for delta smelt and maintain louver efficiency for other species that do not exhibit the inverse relationship between approach velocity and louver efficiency (e.g., chinook salmon and steelhead).

## DISCUSSION

Fish entrained to the TFCF often arrive individually and, thus, 0 and 1 are regular observations of the proportion of fish successfully salvaged. This result provides typically bimodal distributions in the secondary louver efficiency data (figures 4-8). In contrast, experimental injection of fish provided a normally distributed louver efficiency distribution (figure 9). Experimental analysis of factors influencing louver efficiency provided an effective approach for

establishing statistical significance of factors. However, for exploring a large number of potential influences on louver efficiency for 33 or more species of fish (table 4), the empirical approach is more efficient.

In the first experiments conducted, we found that the two sets of louvers in the secondary channel synergistically produce louver efficiencies up to 30 percent higher than one set of louvers alone (tables 13-1 and 13-2). Splittail released between the louver arrays had less time to orient themselves to the flow than those released in front of the more anterior louver array. Yet, the magnitude of louver efficiency increase with two louver arrays suggests the two sets of louver arrays are important in achieving satisfactory efficiencies. Thus, a series of barriers and screens may be more efficient than any one screen alone.

The size of fish appeared related to secondary louver efficiency for only one of the five target species we studied (table 14). American shad larger than 30-mm (1.2 in) FL were louvered less successfully than those smaller than 30-mm (1.2 in) FL. This relationship between size and louver efficiency lends itself to the experimental analysis of louver efficiency. Therefore, future research might use an experimental approach to determine if the observed variance in louver efficiencies with size are statistically significant.

This research also pointed out an unexpected result with respect to "take" of listed species at the TFCF. Currently, if Reclamation improves delta smelt louver efficiency at the TFCF, the official "take" is higher.

No consistent relationship between secondary channel approach velocity and splittail was evident. However, through inspection of the empirical data, relationships between secondary channel velocity did appear for delta smelt and striped bass. The highest delta smelt louver efficiency occurs at velocities lower than 0.33 m/s (1.09 ft/s).

TABLE 13-1.—Louver efficiency for those splittail released in front of both secondary louver arrays at the TFCF, March 1999 – May 1999

| | Day | Night |
|---|---|---|
| No net | 81.7 | 66.4 |
| Control net | 91.4 | 72.3 |
| Vegetation net | 73.2 | 66.5 |

TABLE 13-2.—Louver efficiency for those splittail released between the secondary louver arrays

| | Day | Night |
|---|---|---|
| No net | 51.1 | 47.8 |
| Control net | 57.2 | 55.0 |
| Vegetation net | 47.4 | 41.2 |

TABLE 14.—Percentage of two size ranges of target species successfully louvered at the TFCF March 1996 – November 1997

| Species | Efficiency < 30 mm FL | n | Efficiency 30 mm FL | n |
|---|---|---|---|---|
| American shad | 55.8 | 138 | 39.3 | 1848 |
| Chinook salmon | — | 0 | 85.0 | 1890 |
| Delta smelt | 64.2 | 1044 | 72.1 | 68 |
| Striped bass | 59.3 | 3184 | 65.7 | 833 |
| Splittail | 78.1 | 73 | 70.2 | 692 |

Similarly, striped bass show the highest louver efficiency at velocities below 0.33 m/s (1.09 ft/s), and the louver efficiency was positively related to bypass ratio (table 10). Secondary louver efficiency for chinook salmon was highest when channel velocity exceeded 0.94 m/s (3.1 ft/s). Logistic regression showed approach velocity was positively related to chinook salmon louver efficiency. We summarize these results into a suggested operations table for the secondary channel (table 15) with respect to channel velocity, bypass ratio, and time of year.

TABLE 15.— Proposed changes to operations for secondary louver channel at the TFCF. The recommended secondary channel approach velocity appears on the same line as the species for which the recommendation is intended. Justification for these recommended velocities appears in this section and the Results section

| Season | Species Found in Salvage | Approach Velocity Recommended for Secondary Channel | Bypass Ratio Recommended for Secondary Channel |
|---|---|---|---|
| Spring | Delta smelt, Chinook salmon, Striped bass | < 0.33 m/s (1.09 ft/s) | |
| Summer and fall | Striped bass | < 0.33 m/s (1.09 ft/s) | 1.6 |
| Winter | Chinook salmon, Striped bass | > 0.94 m/s (3.1 ft/s) | |

# CONCLUSIONS

We suggest average approach velocity in the secondary channel be maintained below 0.33 m/s (1.09 ft/s) year-round, except when chinook salmon are present at the TFCF. When salmon are present, average velocity in the secondary channel should, if possible, equal or exceed 0.94 m/s (3.1 ft/s).

To understand louver efficiency at the TFCF, emphasis should be placed on experimental analysis of independent variables such as time of day, debris load, approach velocity, bypass ratio, and temperature. An experimental approach will require the use of the Tracy Aquaculture Facility (TAF); resources to maintain the TAF are an important part of this experimental approach.

When new agreements are prepared for the Tracy Fish Collection Facility, new "take" calculations could include "take" reductions for demonstrated improvements in louver efficiency. In addition, allowance should be made in the agreement for future research to improve "take" calculations.

## ACKNOWLEDGMENTS

This study was funded by Reclamation's Mid-Pacific Region (Sacramento, California) and the Denver Technical Service Center. We thank Susan Durham and Cynthia Wilson for assistance with the data analysis. Jerry Morinaka, Kevan Urquahart, and staff from the California Department of Fish and Game were indispensable. Ron Silva and Gary Jordan and the staff in Tracy, California, provided logistical support. Ray Bark, Rafael Lopez, Louis Helfrich, and Johnson Wang provided valuable assistance with the field experiments. Catherine Patrick formatted this report and provided office support. Finally, we thank Charles Liston, Tracy Facilities Research Director; Ron Brockman, Mid-Pacific Region Fisheries Projects Coordinator; and Diana Weigmann, Fisheries Applications Research Group Manager, for program guidance.

## REFERENCES

AFS. 1991. *Common and Scientific Names of Fishes from the United States and Canada.* 5th Edition. American Fisheries Society. Bethesda, Maryland.

Bates, D.W., O. Logan, and E.A. Pesonen. 1960. *Efficiency Evaluation,* Tracy Fish Collection Facility, Central Valley Project, California. U.S. Fish and Wildlife Service. Seattle, Washington, 67 pp.

Bowen, M.D., S.M. Siegfried, C.R. Liston, L. Hess, and C.A. Karp. 1998. Tracy Fish Collection Facility Studies, California, Volume 7. *Fish Collections and Secondary Louver Efficiency at the Tracy Fish Collection Facility: October 1993 to September 1995.* Bureau of Reclamation, Technical Services Center, Denver, Colorado.

SAS Institute Inc., 1999-2001. *SAS/STAT User's Guide.* Version 8. Sas Institute Inc. Cary, North Carolina.

Hosmer, D.W., and S. Lemeshow. 1989. *Applied Logistic Regression.* John Wiley and Sons: New York, New York.

Karp, C.A., L. Hess, and C.R. Liston. 1995. Tracy Fish Collection Facility Studies, California, Volume 3. *Re-evaluation of louver efficiencies for juvenile chinook salmon and striped bass at the Tracy Fish Collection Facility, Tracy, California, 1993.* Bureau of Reclamation, Technical Services Center, Denver, Colorado.

U.S. Department of the Interior. 1957. *Fish protection at the Tracy Pumping Plant.* Bureau of Reclamation, Region 2, Sacramento, California.

Attachment 18

**5-YEAR REVIEW**
March 31, 2004

Species under review: *Hypomesus transpacificus* (delta smelt)

FR Notice: Federal Register 68(148):45270-45271 on August 1, 2003

Lead Field Office: Sacramento Fish and Wildlife Office (916) 414-6700

Name of Reviewer(s): Ryan Olah and Michael Nepstad (916) 414-6625

Cooperating Field Office(s): Not Applicable

Lead Region: California/Nevada Operations Office, Diane Elam, 916/414-6464

BACKGROUND

**1. Existing Recovery Priority Number:**

The current U.S. Fish and Wildlife Service (Service) Recovery Plan (1996) for delta smelt assigned a recovery potential of 2C. A listed species is assigned a recovery priority number from 1 (highest) to 18 (lowest) according to the degree of threats, recovery potential and taxonomic distinctness. In addition, a species' rank may be elevated by adding a C designation to its numerical rank to indicate that there is some degree of conflict between the species' conservation efforts and economic development associated with its recovery. Recovery priority numbers are based on criteria published the Federal Register Notice (48 FR 43098; September 21, 1983). At the time of listing, Delta smelt was under a high degree of threat from the severe 1987-1992 California drought. The species persisted in small numbers and rebounded to pre-decline levels in 1993, suggesting that its recovery potential is fairly high. The subsequent decline in 1994, a critical water year, to a then all-time low annual abundance index of 102 (Fall Midwater Trawl Survey (FMWT)), however, illustrates the high degree of threat that neutralizes gains in abundance that result from good water years. More recent abundance indices have varied, but overall, the trend is still negative.

**2. Most recent Species Status as reported to Congress in the Biennial Report:**

The 2003 Species Status as reported to Congress in the Biennial Report (Service 2003a) contained the following information:

2003 Listing Status: T, CH
2003 Population Status: U
2003 Recovery Achieved: 2
2003 Recovery Priority: 2C
2003 Is Recovery Plan Under development: No (Final plan completed 1996)

2003 Active Approved Recovery Team: No

2003 Last Year of Population Survey: There presently is no survey which provides data which can be used for population estimates. All of the surveys described below provide limited data on seasonal distribution and abundance for a portion of the smelt life history.

2003 Controlled Propagation: Yes, for research program, objectives met

Species Comments: Not enough known as population information is based on abundance indices

Recovery Plan Comments: 5 year review ongoing, plan set recovery criteria which are now known to be incorrect, has not met delisting criteria. (See section 11 below and appendix A)

**3. Listing History:**

**a. Original Listing:**

The Service was petitioned to list the delta smelt as endangered on June 26, 1990. The Service proposed the species as threatened with critical habitat on September 27, 1991. The species was listed as threatened in Federal Register 58:12863 on March 5, 1993. Critical habitat was designated in Federal Register 59:65256 on December 19, 1994.

**b. Revised Listing:** Not Applicable

**4. Associated Listings:** Not Applicable

**5. Review History:** Not Applicable

**6. Recovery Plan or Outline:**

The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes was signed and approved on November 26, 1996. A recovery team assisted in the preparation of the plan; Dr. Peter Moyle of the University of California, Davis was the team leader. (See #11 and #12 below for a discussion of the Recovery Plan and Appendix A for recommendations concerning the Recovery Plan).

**7. Reference Point Document:**

The March 5, 1993 Final Rule (Service 1993) is the most recent comprehensive analysis of the species status and will be used as the reference point document.

The following is the five factor analysis as published in the 1993 Final Rule (Note that the citations in this section are located within Appendix C):

*A. The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range.*

*The delta smelt was one of the most common and abundant pelagic fish caught by California Department of Fish and Game trawl surveys in the Delta during the early 1970's (Stevens and Miller 1983, Moyle et al. 1989, Stevens et al. 1990). Its distribution once ranged from western Suisun Bay upstream to Sacramento on the Sacramento River and to Mossdale on the San Joaquin River (Radtke 1966, Moyle 1976, Moyle et al. 1992). Smelt populations fluctuated a great deal in the past, but after 1981 began a precipitous decline. Over the last 20 years, the population has experienced a ten-fold decline in numbers, and since 1982, has remained at extremely low levels. Recent population abundance indices confirm that the species has not shown any significant signs of recovery (Moyle and Herbold 1989, Moyle et al. 1989, Stevens et al. 1990, Moyle et al. 1992, Sweetnam 1992). This species' pelagic life history, dependence on pelagic microzooplankton, 1-year life span, and low fecundity are characteristics of a fish species that is affected greatly by perturbations to its reproductive habitat or larval nursery areas. Under existing levels of water development, the delta smelt is especially vulnerable during protracted drought periods. Deleterious effects of the present drought period would be exacerbated if additional alterations in hydrology caused by reductions of freshwater inflows to the Delta alter the timing and/or duration of water exports. A weak stock-recruitment relationship (i.e., little evidence of the effect of parent population size on subsequent recruitment) strongly suggests that environmental or habitat factors are severely limiting delta smelt abundance, even during those years when adults may be abundant (Moyle et al. 1992).*

*Moyle et al. (1989) reported multiple and synergistic causes of the delta smelt decline in the following order of importance: (1) Reduced river outflows, primarily in the Sacramento and San Joaquin Rivers, and their tributaries, (2) extremely high river outflows in years with unusually high rainfall, (3) entrainment mortality caused by water diversion, (4) human and natural perturbations to the smelt's food web, (5) presence of toxic substances in the aquatic habitat (e.g., agricultural and industrial chemicals, heavy metals, etc.), and (6) loss of genetic integrity because of a sharply curtailed delta smelt population. This small delta smelt population may become displaced by the wagasaki, or Japanese smelt (Hypomesus nipponensis), which was inadvertently introduced into reservoirs of the Sacramento River drainage by the California Department of Fish and Game (Moyle 1976).*

*Delta water diversions and exports presently total up to about nine million acre-feet per year. State and Federal projects presently export about six million acre-feet per year when there is sufficient water available, and in-Delta agricultural uses result in diversion of about three million additional acre-feet per year. Plans currently being prepared propose to greatly increase exports and diversions in the future. The Service is aware of 21 major Central Valley Project, State Water Project, or private organization proposals that will result in increased water exports from the Delta, reduce water inflow to the Delta, change the timing and volume of Delta inflow, or increase heavy metal contamination into the Delta. These proposed projects or actions include but are not limited to: Los Banos Grandes Reservoir, South Delta Water Management Program, South Delta Water Barriers Project, North Delta Water Management Project, West Delta Water Management Project, Coastal Aqueduct proposal, Delta Wetlands Corporation*

*Water Storage Project, Central Valley Project contract renewals, Los Vaqueros Reservoir, the Central Valley Project and State Water Project wheeling purchase agreement, reactivation of the San Luis Drain, Stanislaus-Calaveras River Basin Water Use Program, Kern Water Bank, Arvin Edison water storage and exchange proposal, and State Water Project Pump additions.*

*A significant change in in-Delta diversions is unlikely; if anything, a slight decrease in in-Delta agricultural use is probable. The Federal pumping plant has been operated at capacity for many years except for a very few drought years, so increased exports at this plant appear unlikely. The State Water Project pumping plant and the capacity of the State Aqueduct have considerable unused capacity, however. A table of past and projected State Water Project deliveries from Delta sources during the years of 1962 to 2035 are listed in California Department of Water Resources (1992). In the 1980's, deliveries ranged from 1.5 million acre-feet to 2.8 million acre-feet. By 1993, if enough water is available, deliveries could increase to as much as 3.8 million acre-feet. By 2010, deliveries of up to 4.2 million acre-feet are possible.*

*Since 1983, the proportion of water exported from the Delta during October through March has been higher than in earlier years (Moyle et al. 1992). The timing of these proportionally higher exports have coincided with the delta smelt's spawning season. Federal and State water diversion projects in the southern Delta export, by absolute volume, mostly Sacramento River water with some San Joaquin River water. During periods of high export pumping and low to moderate river outflows, however, reaches of the San Joaquin River reverse direction and flow to the pumping plants located in the southern Delta. The State-operated pumping plant presently exports water at rates up to 6,400 cubic feet per second (cfs). The State is considering proposals to export an additional 3,900 cfs. The Federal pumping plant can export water at rates up to 4,600 cfs. In addition, local private diverters export up to 5,000 cfs from about 1,800 diversions scattered throughout the Delta.*

*When total diversion rates are high relative to Delta outflow and the lower San Joaquin River and other channels have a net upstream (i.e., reverse or negative) flow, out-migrating larval and juvenile fish of many species become disoriented. Large mortalities occur as a result of entrainment and predation by striped bass at the various pumping plants and other water diversion sites. Net positive riverine flows and estuarine outflows of sufficient magnitude are required for delta smelt larvae to be carried downstream into the upper end of the mixing zone of the estuary rather than upstream to the pumping plants.*

*In recent years, the number of days of reversed San Joaquin River flow have increased, particularly during the February-June spawning months for delta smelt (Moyle et al. 1992). All size classes of delta smelt suffer near total loss when they are entrained by the pumping plants and diversions in the south Delta. Very few are effectively salvaged at the State and Federal pumping plant screens. The few delta smelt that are transported into water project reservoirs or canals fail to reproduce. This species' embryonic, larval, and postlarval mortality rates also will become higher as reduced western Delta flows*

*allow increases in the salinity level and relocation of the mixing zone.*

*The delta smelt is adapted for life in the mixing zone (brackish water/freshwater interface) of the Sacramento-San Joaquin estuary. The estuary is an ecosystem where the mixing zone and salinity levels are determined by the interaction of river outflow and tidal action. Moyle et al. (1992) reported that delta smelt were most abundant in shallow, low salinity water associated with the mixing zone, except when they spawned. Their analysis showed that smelt were collected from water with a mean salinity of 2 parts per thousand (ppt) with a mean temperature of 15 degrees Celsius (C), but were found in salinities ranging from 0-14 ppt at temperatures ranging from 6-23 degrees C. The larvae require the high microzooplankton densities produced by the mixing zone environment. The best survival and growth of smelt larvae occurs when the mixing zone occupies a large geographic area, including extensive shoal regions that provide suitable spawning substrates within the euphotic zone (depths less than 4 m). Sixty-two percent of delta smelt collected in Suisun Bay occurred at 3 sampling stations with depths less than 4 m; the remaining 38 percent were caught at 6 deeper stations.*

*During periods of drought and increased water diversions, the mixing zone and associated smelt populations are shifted farther upstream in the Delta. During years prior to 1984, the mixing zone was located in Suisun Bay during October through March (except in months with exceptionally high outflows or during years of extreme drought). From April through September, the mixing zone usually was found upstream in the channels of the rivers. Since 1984, with the exception of the record flood outflows of 1986, the mixing zone has been located primarily in the river channels during the entire year because of increased water exports and diversions. When located upstream, the mixing zone becomes confined to the deep river channels, becomes smaller in total surface area, contains very few shoal areas of suitable spawning substrates, may have swifter, more turbulent water currents, and lacks high zooplankton productivity. Delta smelt reproduction very likely is adversely affected now that the mixing zone is located in the main channels of the Delta, east of Suisun Bay (Moyle et al. 1992). In 1982, the decline of the delta smelt population in response to the shifted location of the mixing zone was significant. In all respects, the upstream river channels are much less favorable for the spawning and survival of the smelt. The decline of the delta smelt population since 1981 has been concurrent with an increasing amount and proportion of freshwater diversions that confine the mixing zone to the narrow, deep, and less productive channels in the lower rivers.*

*B. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes*

*Not known to be applicable; however, the delta smelt may be harvested as a non-target by-catch in commercial bait fisheries for other baitfish species. Some scientific collecting is conducted for the delta smelt; however, these activities do not appear to be adversely affecting this species. Native Americans historically harvested delta smelt for food, but modern Native Americans are not known to be harvesting this fish. No recreational or educational uses of this animal are expected to affect the delta smelt population.*

*C. Disease or Predation*

*Not known to be applicable. However, the introduced striped bass may have caused an increase in predation on all size classes of the delta smelt. An effort by the California Department of Fish and Game is underway to compensate for striped bass population mortalities caused by water export projects. The 1991 striped bass stock was very low relative to the population in the 1960's. The striped bass compensation program annually releases 1-2 million juvenile hatchery reared striped bass in the estuary in an effort to rebuild the population. This year the Director of the California Department of Fish and Game decided not to release striped bass because of the potential harm they would cause to the federally threatened Sacramento River winter-run chinook salmon.*

*D. The Inadequacy of Existing Regulatory Mechanisms*

NOTE: This paragraph from the original delta smelt listing is no longer correct. The delta smelt was subsequently listed as threatened under the California Endangered Species Act. *Regulatory mechanisms currently in effect do not provide adequate protection for the delta smelt or its habitat. This species is not listed by the State of California. The California Fish and Game Commission ruled on August 30, 1990, that a petition to the State to list the species was unwarranted, rejecting the California Department of Fish and Game's recommendation to list the delta smelt as a threatened species under State authority (Stevens et al. 1990). State listing would have provided some measure of protection to the species because State agencies would have been required to consult with the California Department to Fish and Game if any project they funded or carried out would adversely affect the delta smelt. However, even if the State of California had listed the delta smelt, the species would not have been protected from the adverse effects of Federal actions.*

*Suisun Bay is the best known nursery habitat for this species' reproduction and larval survival, but the habitat has been deleteriously altered because of higher salinities in spring. These higher salinities are caused by the large number of freshwater diversions that allow brackish seawater to intrude farther upstream. At present, there are relatively few periods when freshwater outflow volumes through the Delta and Suisun Bay of any significance are mandated for wildlife or fisheries. Federal and State agencies had planned to increase 1991 and probably 1992 water supplies for out-of-stream uses at the expense of environmental protection of estuarine fish and wildlife resources in the fifth and potentially sixth years of drought (Morat 1991). Because of significantly higher than normal precipitation and subsequent higher instream flows during March, 1991, a State agency request for relaxation of Delta water quality standards was withdrawn. It is likely, should the severe California drought continue, that this water quality relaxation action will be requested again in the near future to favor out-of-stream water use over the need to protect aquatic habitats for fish and wildlife.*

*Present regulatory processes do not ensure that water inflows to Suisun Bay and the western Sacramento-San Joaquin estuary will be adequate to maintain the mixing zone near or in Suisun Bay to benefit delta smelt and other fish and wildlife. The California*

*State Water Resources Control Board (Board) has the authority to condition or require changes in the amount of water inflow and the amount of water exported or diverted from the Delta. At the Board's Water Quality/Water Rights Hearings in 1987, a Service biologist testified that the delta smelt had been recommended for addition to the Federal Animal Notice of Review as a category 1 candidate species (Lorentzen 1987). The Board has not taken regulatory or legal action to protect this animal or its habitat during the 4 years since the Service expressed its concern for several species native to Sacramento-San Joaquin estuary. On December 9, 1992, the Board released a copy of Water Rights Decision 1630 (D-1630), San Francisco Bay/Sacramento-San Joaquin Estuary (California State Water Resources Control Board 1992). A meeting to consider adoption of D-1630 is scheduled for January 25, 1993. In whatever form it is finally adopted by the Board, D-1630 will establish minimum levels of public trust uses of the delta for up to 5 years. Subsequently, long-term standards will be prepared and adopted.*

*Implementation of the draft decision as prepared would result in improved habitat conditions for the delta smelt. The Service is presently in the process of analyzing the draft terms and conditions to determine to what extent delta smelt will be benefited, if the decision is adopted and implemented. However, even assuming immediate adoption and implementation of these interim terms and conditions, their adequacy as a regulatory mechanism to protect the delta smelt remains in question. The Service is aware that the salinity standards currently in effect (D-1485) are inconsistently implemented and frequently violated due to operational constraints. Institutional guarantees of compliance have been lacking in the past and are needed in the future.*

*Similarly, the Service is currently analyzing the potential effects on the delta smelt and other fish and wildlife resources in California as a result of the recent enactment of the Central Valley Project Improvement Act (Pub. L. 102-575). Two of the stated purposes of this act are to: "protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley and Trinity River basins of California" and "to contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay/Sacramento-San Joaquin Delta Estuary". Section 3406(b)(2) dedicates annually 800,000 acre-feet of Central Valley Project water for various purposes including the benefit of federally listed species. While the Service is reasonably certain that the delta smelt will realize some benefit from implementation of this Act, the magnitude and timeliness of these protections may be inadequate to prevent the endangerment of the delta smelt. For example, many analysts predict that provisions within the Act will take many years for the courts to resolve. Finally, neither adoption of the State Water Resources Control Board's Decision 1630 or the Central Valley Project Improvement Act protect the delta smelt per se, or provide mechanisms to ensure the continued existence of the species.*

*For the reasons stated above, the Service considers the existing regulatory mechanisms inadequate to assure the long-term existence of delta smelt in Suisun Bay and the Delta.*

*E. Other Natural or Manmade Factors Affecting its Continued Existence*

*The delta smelt is highly vulnerable to extinction because of its short life span, present small population size, and restricted distribution. The limited gene pool may result in depressed reproductive vigor and loss of genetic variation.*

*Poor water quality also may be a threat. All major rivers in this species' historic range are exposed to large volumes of agricultural and industrial chemicals that are applied in the California Central Valley watersheds (Nichols et al. 1986). Agricultural chemicals and their residues, and chemicals originating in urban runoff, find their way into the rivers and estuary. Toxicology studies of rice field irrigation drain water of the Colusa Basin Drainage Canal documented significant toxicity of drain water to striped bass embryos and larvae, medaka larvae, and the major food organism of the striped bass larvae and juveniles, the opposum shrimp (Neomysis mercedis). This drainage canal flows into the Sacramento River just north of the City of Sacramento. The majority of drain water samples collected during April and May 1990 were acutely toxic to striped bass larvae (96-hour exposures), the third consecutive year that the Colusa Basin rice irrigation drain water has been acutely toxic (Bailey et al. 1991). Delta smelt may be similarly affected by agricultural and industrial chemical run-off.*

*Some heavy metal contaminants have been released into the Delta from industrial and mining enterprises. Although the effects of these contaminating compounds on delta smelt larvae and their microzooplankton food resources are not well known, the compounds could potentially adversely affect delta smelt survival. In addition, increases in urban development in the Sacramento Valley will continue to result in concurrent increases in urban runoff. Finally, a proposal to reactivate the San Luis Drain would result in discharge of high levels of selenium from the San Joaquin Valley into the Delta. Selenium has been shown to cause developmental defects in and mortality of wildlife species.*

*In recent years, untreated discharges of ship ballast water introduced nonindigenous aquatic species to the Sacramento-San Joaquin estuary ecosystem (Carlton et al. 1990). Several introduced species adversely affect the delta smelt directly. An Asian clam (Potamocorbula amurensis), introduced as veliger larvae at the beginning of the present drought, was first discovered in Suisun Bay during October 1986. By June 1987, the Asian clam was nearly everywhere in Suisun, San Pablo, and San Francisco Bays irrespective of salinity, water depth, and sediment type at densities greater than 10,000 individuals per square meter. Asian clam densities declined to 4,000 individuals per square meter as the population aged during the year (Carlton et al. 1990). Persistently low river outflow and concomitant elevated salinity levels may have contributed to this species population explosion (Carlton et al. 1990). The Asian clam could potentially play an important role in affecting the phytoplankton dynamics in the estuary. It may have an effect on higher tropic levels by decreasing phytoplankton biomass and by directly consuming Eurytemora affinis copepod nauplii, the primary food of delta smelt.*

*Three non-native species of euryhaline copepods (Sinocalanus doerrii, Pseudodiaptomus forbesi, and Pseudodiaptomus marinus) became established in the Delta between 1978 and 1987 (Carlton et al. 1990), while Eurytemora affinis populations, the native*

*euryhaline copepod, have declined since 1980. It is not known if the introduced species have displaced E. affinis or whether changes in the estuarine ecosystem now favor S. doerrii and the two Pseudodiaptomus species (Moyle et al. 1989). These introduced copepod species are more efficient at avoiding the predation of larval delta smelt. The introduced copepods also exhibit a different swimming behavior that makes them less attractive to feeding delta smelt larvae. Because of reduced food availability or feeding efficiency causing decreased food ingestion rates, weakened delta smelt larvae are more vulnerable to starvation or predation.*

*The significantly altered microzooplankton food web now present in the Suisun Bay-Delta estuary may have decreased the gross growth efficiency of delta smelt larvae. Gross growth efficiency is the proportion of weight-specific food ingestion rate that goes to larval fish body growth. When food ingestion rates are low, gross growth efficiency is low. At low gross growth efficiencies, larval fish take much longer to metamorphose to juveniles. Long larval stage durations increase the likelihood that density-dependent mechanisms (e.g., predators, overgrazing of food resources, etc.) and density-dependent mechanisms (e.g., adverse salinities, temperature, absence of zooplankton, water diversion entrainment and impingement mortality, etc.) would develop to adversely affect survival and recruitment. In temperate latitudes, where spawning is temporally and spatially confined, as it is for the delta smelt, both mortality and growth rates tend to be low. Ingestion in temperate species is relatively low compared to tropical species, and larval stage duration is long and potentially highly variable. Under these circumstances, small changes in either mortality rates or growth rates can have significant adverse effects on recruitment potential (Shepherd and Cushing 1980, Houde 1989). Therefore, the timing of spawning and the availability of favorable spawning sites for adults are added critical elements in the recruitment success of the spawned cohort.*

*The Service has carefully assessed the best scientific and commercial information available regarding the past, present, and future threats faced by this species in this listing determination. The Service acknowledges that available data on the population dynamics of the delta smelt were collected incidental to other investigations and were not intended to provide a population estimate. The Service believes, however, that these data represent the best available information and support the listing of this species. The available data indicate a significant population decline over the last 20 years. Though the current population has remained relatively stable over the last 5 years, it has done so at very low levels. No apparent recovery is occurring. The delta smelt faces threats from a more frequent upstream shift of its aquatic estuarine habitat, and a reduction of available habitat due to drought, replenishment for groundwater overdraft, and water exports and diversions. The shift in location of the mixing zone, as well as the reduced area available to the smelt, is expected to continue in the future. These factors will continue to adversely affect all life stages of the delta smelt. Because the smelt population is at such low levels, this species' 1-year lifespan is also a factor that threatens the species. The failure of a single reproductive season could significantly affect the ability of this species to survive and recover. Based on the evaluation of all available information on population dynamics and threats to this species, the Service has determined that listing as threatened is appropriate at this time.*

## REVIEW

**8. DPS Review - Application of the Distinct Population Segment (DPS) Policy:**

The entire population of delta smelt is listed and nothing in the current science suggests that the delta smelt should be listed as a DPS.

**Status Review**

- **9. Information Review:** Is there new information available that is relevant to this review? Available information is considered to be all information 1) submitted, 2) available to Service employees, or 3) in Service files, during the review.

Yes __X__ (Go to 9. B.) No _____ (End of Review/Go to 14)

9. A. Is there any relevant new information regarding the listed population and/or the species throughout its range with respect to the appropriate application of the DPS policy?

Yes _____ No __X__

Not applicable, as the delta smelt was not listed as a DPS.

9. B. Is there relevant new information addressing the species' biology and status including, but not limited to, population trends, distribution, abundance, demographics, and genetics?

Yes __X__ No _____

Below is a discussion of available new and updated information which addresses delta smelt biology and status.

SURVEYS

The Service is aware of 14 surveys that collect data on delta smelt. See Appendix B for Abundance Indices Tables based on some of the below survey data. The following nine surveys began sampling before the listing in 1993:

(1) California Department of Fish and Game's (CDFG's) Fall Midwater Trawl (FMWT) (1967 to present) (CDFG 2003a). The Fall MWT was initiated by CDFG in 1967 to sample striped bass, a non-native sport fish. In addition to striped bass, CDFG has maintained records of other fish species captured in the samples in most years. This monitoring program currently samples 100 sites from San Pablo Bay in the west to Rio Vista on the lower Sacramento River and to Stockton on the San Joaquin River. Data are collected from September through December using a midwater trawl with a 3.7 square m (39.8 square ft) wide mouth. The FMWT covers the entire range of delta smelt distribution and provides one of the two best measures of delta smelt abundance (Sweetnam and Stevens 1993). The FMWT provides a better measure of abundance than

the Summer Townet Survey (described below) because it catches pre-spawning adult delta smelt (Service 1996). An index based on pre-spawning adults, rather than on juveniles which are vulnerable to high mortality, provides a better estimate of delta smelt stock and recruitment (Service 1996). Although the FMWT was not designed to catch delta smelt and is not as efficient at catching delta smelt compared with the Kodiak trawl (described below), it has been continuously done since 1967 and thus provides a solid base of historical data (Service 1996). Results from this trawl are used to calculate the Delta Smelt Recovery Index as described in the Recovery Plan.

(2) CDFG's San Francisco Bay Midwater Trawl (1980 to present). This trawl catches delta smelt throughout the year in the waters west of the delta seaward to south San Francisco Bay.

(3) CDFG's San Francisco Bay Otter Trawl (1980 to present). This trawl catches delta smelt throughout the year in the waters west of the delta seaward to south San Francisco Bay.

(4) University of California (UC) Davis' Suisun Marsh Otter Trawl (1979 to present). This trawl catches delta smelt in the Suisun Marsh waterways. The Suisun Marsh OT surveys began in 1979 and are conducted by the University of California (UC) Davis as part of a long-term study of the ecology of the entire fish community of the marsh. The survey is funded by California Department of Water Resources (CDWR) in part to determine if management actions in Suisun Marsh are affecting fish communities. The program samples 21 sites monthly in nine sloughs with an otter trawl that drags along the bottom and samples much of the water column in the shallow sloughs. In small sloughs, the trawl samples much of the cross sectional area; in large sloughs, the sampling fraction is smaller. A monthly abundance index is calculated as mean catch per trawl.

(5) Service's Chipps Island Trawl survey (1976 to present). The U.S. Fish and Wildlife Service conducts a sampling program for juvenile salmon in the deep water channel near Chipps Island at the western terminus of the Delta. This trawl also catches delta smelt. A midwater trawl is pulled at the surface for ten 20 minute hauls per day. Data are compiled to produce an index based on the catch per hour of trawling.

(6) Fish salvage at the CVP Tracy Fish Collection Facility (1979 to present) (CDFG 2003b and Service 2003b). This facility salvages smelt throughout the year. The CVP operates fish screening facility to divert fish away from the pump intakes into holding facilities where they are counted, measured, and released. Data collection takes place at two hour intervals when the pumps are operating. Reliable CVP data start in 1979. The pumps are not operated as sampling programs so the amount of "sampling" is related to the amount of water exported, which in turn is related to the amount of water available, water demand, and, in recent years, changes in pump operations to protect migratory salmon, splittail, and delta smelt and to maintain appropriate salinities in Suisun Bay and Marsh. The survival of fish salvaged at the facilities and released into the delta varies by species and environmental factors. At this time, delta smelt mortality from this process is estimated by the Service to be 100%. In addition, the number of smelt salvaged is used to

help determine if an Environmental Water Account (EWA) action needs to be taken. (See 9D below for a discussion of EWA)

(7) Fish salvage at the SWP Skinner Delta Fish Protective Facility in the south Delta (1979 to present) (CDFG 2003b and Service 2003b). This facility salvages smelt throughout the year. The SWP operates a fish screening facility to divert fish away from the pump intakes into holding facilities where they are counted, measured, and released. Data collection takes place at two hour intervals when the pumps are operating. Reliable SWP data start in 1979. The pumps are not operated as sampling programs so the amount of "sampling" is related to the amount of water exported, which in turn is related to the amount of water available, water demand, and, in recent years, changes in pump operations to protect migratory salmon, splittail, and delta smelt and to maintain appropriate salinities in Suisun Bay and Marsh. The survival of fish salvaged at the facilities and released into the delta varies by species and environmental factors. At this time, delta smelt mortality from this process is estimated by the Service to be 100%. In addition, the number of smelt salvaged is used to help determine if an EWA action needs to be taken.

(8) Service's Delta Beach Seine Survey (1976 to present). This survey can catch delta smelt throughout the year. The survey provides the broadest geographical coverage of all of the sampling programs but is focused on outmigrating juvenile salmonids.

(9) CDFG's Summer Townet Survey (1959 to present) (CDFG 2003c). This trawl is operated in the summer, catches juvenile and adult delta smelt, and provides one of the two best measures of delta smelt abundance (Sweetnam and Stevens 1993). The CDFG summer townet survey began in 1959 to provide an index of striped bass abundance. It samples YOY fish twice monthly at 30 sites using oblique tows in mid-channel. Starting and ending dates vary from year to year. Sample sites are located throughout the Delta, Suisun Bay, and San Pablo Bay. Data for species other than striped bass were not regularly recorded until after 1962, but were also not recorded in 1966, 1967, and 1968.

(10) CDFG's Striped bass egg and larval survey (1968 to 1995) (Interagency Ecological Program 1996). This survey sampled in the spring and caught larval delta smelt.

The following five surveys began sampling delta smelt since the listing:

(11) IEP's 20mm survey (1995 to present) (CDFG 2003d). This survey runs in the spring to catch larval and juvenile delta smelt. This survey's information is used to help determine smelt distributions in the delta and to helps determine if an EWA action needs to be taken.

(12) U.S. Army Corps of Engineers' (Corps) Napa River Survey (2001 to present) (Corps 2002 and 2003). This survey catches delta smelt in the Napa River. This survey exists in association with a flood control and ecosystem restoration project in the Napa River. It is performed by consultants under contract to the Corps, and involves a range of sampling techniques including beach seine, purse seine, otter trawl, fyke nets, and a 20 mm (0.8 in)

size class surveys. The Napa River Survey began sampling in March 2001 and has detected smelt (Corps 2002, 2003) but the data are too recent and of too short a term to be useful for an abundance index. The survey is scheduled to be completed in 2007 or 2008, after 7 years of data collection. In addition, the Napa River is less well understood in terms of relationships between outflow, smelt habitat, and smelt production, than are the Central Valley rivers and the Delta (see section 9.I. below).

(13) IEP's Spring Kodiak Trawl (2002 to present) (CDFG 2003e). This trawl, designed specifically to sample delta smelt, is pulled by two boats and samples the upper water column. This survey catches adult delta smelt and can help determine where adult smelt are distributed in the delta.

(14) North Bay Aqueduct Larval Fish Survey (1996 to present) (CDFG 2003f). This trawl samples north delta in the spring for larval delta smelt.

DENSITY DEPENDENCE

Attempts have been made to answer the questions of density dependence and population size for delta smelt, but to date there is no expert consensus on whether delta smelt populations display density dependence or density independence. Density dependence can be broadly defined as the case where more individuals of one life stage do not necessarily result in more adults and implies that there is a finite carrying capacity. There is considerable disagreement among experts over whether the data show that delta smelt exhibit density dependence during part or all of their life cycle (CALFED 2001, 2003a). This question is relatively controversial because of its ultimate potential implication for management of water diversions within the Delta. Bennett used traditional stock-recruitment analysis and calculations of mortality between life stages to conclude that density dependence has regulated delta smelt abundance over the period of record (CALFED 2001). However, Bennett (CALFED 2002a) stated that the available evidence suggests density dependence occurs infrequently and was most evident in the 1970's. Finally, Bennett (2003) stated that density dependant regulation may now be occurring at lower levels of abundance during late-summer than before the population decline.

A preliminary analysis by the California Department of Fish and Game (CDFG) (2003g) strongly suggests that the delta smelt population is largely regulated by density independent factors, particularly spring temperature conditions, the location of X2, and possibly the impact of export losses in dry years. CDFG (2003g) does not believe density dependant mortality currently plays a substantial role in determining annual delta smelt abundance for three fundamental reasons: 1) no credible mechanism for density dependent regulation has been presented; 2) smelt are currently not abundant relative to their past abundance or relative to the other species living in the delta, and; 3) the statistical evidence for density dependence is very weak.

ROLE OF TWO YEAR OLDS

Delta smelt typically live one year, but approximately 3-8% of individuals live two years

(Bennett 2003). Two year old fish have 3 to 5 times the fecundity of 1 year fish. These fish could be important for carrying the population over through years of poor year class strength (fewer individuals). However, there is no information at this time which describes their relative contribution to spawning during years following poor recruitment (CALFED 2003a, CDFG 2003g, and Bennett 2003).

9.C. Is there relevant new information addressing habitat conditions including, but not limited to, amount, distribution, and suitability?

Yes ___X___ (See Section 9D) No _____

9.D. Is there relevant new information addressing conservation measures that have been implemented that benefit the species?

Yes ___X___ No _____

FISH SCREENS

The CALFED Ecosystem Restoration Program has funded the construction of screens on several water diversions within the range of delta smelt, including an agricultural diversion on Hastings Slough, and the City of Sacramento's diversion on the Sacramento River (CALFED 2003b). These screens are designed to help prevent help prevent adult delta smelt from becoming entrained by the physical barrier of the screen as well as sweeping velocities that would carry delta smelt past the point of diversion (CALFED 2003b). While there remain over 1,800 diversions within the range of delta smelt, the Service recognizes that the actions of CALFED to date represent progress towards eliminating entrainment of delta smelt in unscreened diversions (CDWR 1995).

ECOSYSTEM RESTORATION

The CALFED Ecosystem Restoration Program has funded the restoration of multiple habitats at several locations within the range of delta smelt, including Canal ranch, Liberty Island, and McCormack-Williamson Tract (CALFED 2003b). The CALFED Ecosystem Restoration Program has also funded the restoration of shallow water tidal and marsh habitat at several locations within the range of delta smelt, including Fay Island, Franks Tract, Big Break, Lower Sherman Lake, and Prospect Island (CALFED 2003b). The Service recognizes that the actions of CALFED to date represent progress towards enhancing and/or restoring additional habitat for the delta smelt.

WATER MANAGEMENT

Since the listing of delta smelt, our body of knowledge of delta smelt life history and population dynamics has increased. Water and fishery management actions have become more focused on

addressing specific life history requirements rather than prescriptive limitations on exports. Both VAMP and the EWA, described below, are water management tools which are designed to address specific needs of delta smelt. As our scientific understanding of delta smelt increases, we expect that these or similar programs would adapt to our current state of knowledge.

*VAMP*

It has been postulated that the Vernalis Adaptive Management Program (VAMP) has changed water movement in the southern Delta during the early delta smelt life history (CALFED 2001). The assumptions and information leading to this hypothesis are as follows: 1) since the initiation of VAMP in 1996, modeling and field data demonstrate that April through May net flows in southern Delta channels are more positive than occurred pre-VAMP, with less water movement towards the pumps; 2) since VAMP started, the projects have exceeded the red light take level more often than they would have pre-VAMP; 3) the VAMP flows and pumping restrictions provide better spawning and rearing conditions in the south Delta than was formerly possible; 4) with better rearing conditions, the larvae in the south Delta that are not entrained grow to the size (greater than or equal to 20 mm) that is successfully salvaged and counted at the intakes; 5) taking this model to its logical conclusion, the projects are not removing more fish than they did historically, they are removing more older fish (i.e. in the past the larval fish did not reach the salvageable size and went down the aqueduct without being counted), and; 6) on balance, VAMP effects on delta smelt are likely to be or slightly positive since delaying higher levels of exports may allow more of the oldest fish to avoid entrainment.

*ENVIRONMENTAL WATER ACCOUNT*

CALFED has undertaken efforts to minimize the take of delta smelt at the SWP and CVP since 2001 water year using their Environmental Water Account (EWA). The EWA is designed to balance two conflicting objectives: (1) to protect federally listed fish and (2) avoid interruptions of water deliveries by the state and federal export facilities. The EWA is built on the premise that water can be obtained and banked until needed. When large numbers of delta smelt are being taken at the state and federal export facilities, pumping is reduced and water stored south of the delta pumps is delivered in place of water not pumped. The effectiveness of EWA is governed by two factors: its ability to acquire sufficient water and the surplus pumping capacity at the state and federal export facilities needed to bank the water (Service 2003c).

EWA is managed by an interagency team which has the responsibility of determining if and when EWA assets are used. The EWA is currently being resized to account for proposed increases in water exports at the state and federal export facilities. In addition, the EWA is currently being reviewed to determine if it was successful in its first 3 years of operation. The current EWA was established as a temporary program, lasting only four years with the ability to be extended in the future. It is expected that the EWA will continue, although it has not yet become a permanent program. EWA actions for smelt are taken to reduce pumping at the CVP and SWP when high numbers of smelt are in the south delta. However, at this time it is unclear what, if any, effect EWA actions have had on the delta smelt population. The last 3 years of survey data show declining numbers of delta smelt (see Appendix B) (CDFG 2003g). However, 3 years of operation are insufficient to determine EWA's impact on delta smelt, for even if abundance indices were to indicate increases, they represent too limited a timeframe to overcome natural variance (Service 2003c). The information currently available is inconclusive, and as a

result we are unable to accurately assess the effects of VAMP and EWA. What is clear is that to the extent flow management affects delta smelt viability, both programs contribute to delta smelt conservation.

9. E. Is there relevant new information addressing species' existing threats status and/or trends since the last review?

Yes __X__ No

New information relating to existing threats include water flow, water diversions, proposed modifications to the water system, and continuing inadequacy of existing regulatory mechanisms. Please refer to section #13 (5 factor analysis) for an in-depth discussion on each issue.

9. F. Is there relevant new information addressing new threats since the last review?

Yes __X__ No _____

New information relating to new threats include the South Delta Temporary Barriers, and possible disease, introduced species, predation, discharge of ballast water, food availability, genetics, and other environmental issues. Please refer to section #13 (5 factor analysis) for an in-depth discussion on each issue.

9. G. Is there relevant new information to suggest a change in species taxonomy?

Yes _____ No __X__

Stanley *et al.* (1995) confirmed that delta smelt is a genetically distinct species. This does not change our understanding of the species as cited in the reference point document.

9. H. Have any improved analytic methods resulted in relevant new information?

Yes __X__ No _____

POPULATION TREND

A number of surveys have been conducted both prior to and since the 1993 listing, as described in section 9B. The data gathered from these surveys provide abundance indices for delta smelt (see Appendix B). The two-year running average of the Delta Smelt Recovery Index for 2003, as determined from the FMWT, is the second lowest since the species was listed (Service 2003d). The Summer Tow Net Survey data show an almost complete disappearance of juvenile delta smelt in the south delta sampling stations by the mid-1970s (CDFG 2003g). Moyle (2003),

stated that the analysis of 22 years of monthly sampling data from Suisun Marsh shows that the delta smelt have still not recovered to their former abundance, although there has been a general increase in numbers since their low point during a long period of drought (Matern *et al.* 2002) (see Appendix B). From these indices, the Service has concluded that the delta smelt abundance has not recovered to its pre-decline (prior to 1982) levels.

In addition, the San Luis & Delta-Mendota Water Authority (2002) submitted an analysis of population trend on delta smelt adults. Based on four analyses (simple moving average, Lowess smoothing, linear splines smoothing, and polynomial trend smoothing) of Fall Midwater Trawl (FMWT) data, they asserted that delta smelt have exhibited an increasing population trend since the mid-1980's. USGS (2003) conducted a peer review of the San Luis & Delta-Mendota Water Authority (2002) submission. Overall, the peer reviewers (USGS 2003) concluded that the authors failed to demonstrate a positive trend in smelt abundance. Rather than demonstrating a positive trend, the USGS review (2003) indicated that large inter-annual variability is notable and that such variability is expected from a species with this life cycle.

In summary, we believe that there is little compelling information which would suggest that delta smelt populations are increasing over pre-decline levels. However, we recognize that the current available scientific information on delta smelt abundance is somewhat imprecise. We anticipate that research efforts will continue to focus on the development of more reliable population estimates for use in population trend analyses.

POPULATION SIZE

Many individuals and organizations have strongly suggested that abundance indices are inadequate to meet management needs and that population estimates should be made for delta smelt. A population estimate for delta smelt may permit more easily justified take limits, better assessments of population dynamics and extinction coefficients, better understanding of the trophic dynamics of the delta, and better public education efforts. However, there are many challenges associated with determining population size for delta smelt (Herbold 1996).

Surveys of abundance in one area can sometimes be generalized over an entire population. Most often in fisheries science, this involves counts of individuals at a point or points where the entire population must pass. For some species such as salmon, fish passage rates at fish ladders or carcass counts on spawning grounds can give reasonably adequate estimates of total population size (Herbold 1996). However, these methods are not possible for use on delta smelt.

Populations that spend at least part of their life cycle in a discrete area permit estimates of total population size. Fish which aggregate in large, monospecific, and concentrated schools can be adequately estimated through hydroacoustic surveys. The small, mixed species aggregations in the entrapment zone, combined with the delta smelt's frequent presence in shallow water habitats

where hydroacoustic gear is least effective; make such estimation procedures unsuitable for delta smelt (Herbold 1996).

Species that are regularly or randomly distributed within a well defined habitat permit counts in part of the habitat to be confidently expanded to the entire habitat. Species, like delta smelt, whose distributional patterns are unknown but which are likely to demonstrate different abundances and distributional patterns in different parts of their range are unlikely to be estimated with any useful degree of accuracy. For example, capture of two delta smelt in July in Suisun Marsh at a salinity of 10 parts per thousand (ppt), conditions under which they have never been abundant, would mean something quite different from a catch of 2 delta smelt at Chipps Island in October at a salinity of 2 ppt. However, our current understanding of delta smelt is insufficient to translate the difference into a population estimate (Herbold 1996).

The difficulties surrounding delta smelt population estimates are independent of the assumptions regarding gear effectiveness or choice of sampling sites. Thus, more effective sampling gear and wider distribution of surveys cannot wholly overcome the statistical difficulties attending the estimation of population size (Herbold 1996). We would anticipate an increase in confidence in delta smelt population estimates as our knowledge of smelt life history and population dynamics increases.

California Department of Water Resources (CDWR) noted that neither the FMWT nor the Summer Townet Survey provide statistically defensible population abundance estimates. Rosenfield (2003) stated that the Fall Midwater Trawl (FMWT) index is highly variable, at least in part because the sampling gear is not well-suited to detecting delta smelt, as it only briefly samples the surface waters where delta smelt are concentrated. According to Rosenfield (2003), the Kodiak Trawl appears to be a much more effective sampling instrument than the FMWT. The Kodiak Trawl collects fish from the top six feet of the water column (where delta smelt generally reside) while the FMWT collects samples by drawing the trawl diagonally through the water column from the bottom of the river to the top (San Luis & Delta-Mendota Water Authority 2003). The FMWT was not designed for sampling delta smelt and is used because it was implemented in 1967 and so can provide a historical context for relative delta smelt abundance. Unfortunately, the Kodiak Trawl has only been employed recently, and there is no historical context with which to interpret data collected with this gear (Rosenfield 2003).

Bennett (2003) believed that there is little confidence in the effectiveness of the sampling gear of the Fall Midwater Trawl (FMWT) and the Kodiak Trawl. For example, he notes, Kodiak Trawls appear to out-fish the traditional Fall Midwater Trawl in abundance per unit volume, but this knowledge is based on only 2 sampling days and 12 concurrent samples in September 1994. Moreover, there is little certainty of which size classes are missed by the various surveys. The lack of an appropriate abundance measure is currently a crucial factor limiting progress in our understanding of the delta smelt population.

The San Luis & Delta-Mendota Water Authority (2002) estimated the population size of sub-adult delta smelt in the late 1990's to be at least 1 million and as many as 12 million. The estimate was derived by using "side-by-side comparisons" of Fall Midwater Trawl (FMWT) and the Kodiak Trawl made in 1994 by the CDFG.

USGS (2003) and Rosenfield (2003) stated that the assumptions and procedures employed by the San Luis & Delta-Mendota Water Authority (2002) in reinterpreting the FMWT data are flawed. They state that the comparison of catches with different gear and scaling of density data to obtain population estimates is unsupportable as are the estimated correction factors used to offset trawl inefficiency. Also, the use of a correction factor for the Kodiak trawl is questionable. They stated that "scaling up of zero values is found unacceptable given the assumptions listed, life history of the fish, and limitations of the gear." After reviewing USGS (2003) and Rosenfield (2003), we have concluded that the population size estimates presented by San Luis & Delta-Mendota Water Authority (2002) are limited by uncertainties associated with the data set and assumptions. Despite any shortcomings in San Luis & Delta-Mendota Water Authority's (2002) approach, we would encourage continuation of future research efforts to develop reliable population estimates.

PROBABILITY OF EXTINCTION

The San Luis & Delta-Mendota Water Authority (2002) used the population estimates discussed above to estimate the probability of extinction of delta smelt. They estimated that if the sub-adult population is 12 million, then the probability of extinction of delta smelt by 2050 is less than one percent. The USGS (2003) peer reviewers indicated that the use of their population estimates conclusions as a basis for estimating extinction probability would result in a severe underestimate.

USGS reviewers (2003) also felt that risk could not be removed from the analysis as San Luis claims. USGS concluded that risks to the population from both the anthropogenic and climatic factors were major concerns in evaluating abundance indices, regardless of the analytical outcome.

In another analysis, Bennett (2003) investigated the likelihood of delta smelt populations falling below an "effective population size" for two consecutive years. He defines this term to be a Fall Midwater Trawl index of less than 100 for two straight years. This index value of 100 was chosen because it reflects an unprecedented low number of delta smelt. He determined that there was a 13% chance that the delta smelt's population size could fall below an effective population size within the next 10 years, and a 33% chance that the delta smelt's population size could fall below an effective population size by 2025.

9. I. Is there any other relevant new information, such as corrections in historic range, nomenclatural changes, or identification of erroneous information in the list?

Yes ___X___ No _____

Delta smelt are now known to spawn in the Napa River (CDFG 2003d; Corps 2002 and 2003), although it is unclear if these delta smelt are self perpetuating or if frequent recolonization from the delta is necessary to maintain a population there. Several more years of study will be needed in order to determine the role that the Napa River plays in maintaining the species.

10. For population listings only, utilizing the updated species information, provide your assessment with respect to the appropriate application of the DPS policy. See attachment to 5-year review - Consideration of the DPS policy during the 5-year review.

Not applicable, as the delta smelt was not listed as a DPS.

11. Does the species have an up-to-date recovery plan with downlisting and/or delisting criteria (and in some cases uplisting criteria for threatened species) that address both the demographics and the threats to the species?

Yes _____ No ___X___

Our Recovery Plan (Service 1996) stated that recovery of delta smelt should be assessed when the species satisfies abundance and distribution criteria. Distribution criteria were based on catches of smelt in various zones throughout the range of the species. Abundance criteria were that (1) smelt numbers or total catch must equal or exceed 239 (based on the Delta Smelt Recovery Index) for 2 out of 5 years and (2) not fall below 84 for more than two years in a row. If distribution and abundance criteria are met for a five-year period that includes two successive extreme outflow years, one of which is dry or critical, the species will be considered restored.

12. Does the relevant new information indicate that the recovery criteria for downlisting/delisting/uplisting have been met?

Yes ___X___ No ___X___

Our Recovery Plan (Service 1996) stated that delisting would be considered when (1) the five-year period includes two successive extreme outflow years with one year dry or critical and (2) legal mechanisms and interagency agreements are in place to manage the Central Valley Project (CVP), State Water Project (SWP), and other water users to meet these criteria.

During the period from 1998 through 2002 the Delta Smelt Recovery Index, as calculated from the Fall Midwater Trawl data, exceeded 239 in 2 out of 5 years, the 2 year running average never

fell below 84, and the distribution criteria were met (Service 2003d). Therefore, the delta smelt met the abundance and distribution criteria in 2002 based on the five year period from 1998 through 2002. However, threats to delta smelt still remain, and sufficient legal mechanisms and interagency agreements are not in place to assure removal of many of the threat (see section 13 below for a discussion of threats). Therefore, the delisting process has not been initiated. It should also be noted that for 2003, the Delta Smelt Recovery Index did not meet the abundance and distribution criteria outlined in the Recovery Plan.

13. 5-Factor Analysis - Threats Assessment

This section describes the current status of threats to delta smelt, using our 5-factor analysis.

(A) The present or threatened destruction, modification, or curtailment of its habitat or range.

WATER OUTFLOW

Our original listing document states that the delta smelt's decline and sustained low abundance is linked to changes in hydrology resulting from water resource development in and upstream of the Delta. Delta smelt continue to be affected by delta hydrology, which is governed by both climatological and anthropogenic factors.

For fishes and most other Delta organisms, moderately high spring outflows are important because they move fish downstream to shallow water areas in and around Suisun Bay, distant from south Delta diversions (Service 1996). This well mixed shallow water habitat encourages production of phytoplankton and zooplankton that are food for plankton-feeding fish such as delta smelt and their larvae (Service 1996). Low outflows maintain fish larvae and juveniles in the deep, narrow channels of the Delta and Sacramento River where productivity of phytoplankton is lower because much of the water is beyond the reach of sunlight (Service 1996). Presumably, if the food supply is inadequate, fish either starve to death or have increased mortality from secondary effects, as a result of poor nutrition (Service 1996).

Strong statistical relationships between outflow and abundances of American shad, Chinook salmon and longfin smelt (Stevens and Miller 1983), were demonstrated, but no such statistically significant relationship was found for delta smelt. Nevertheless, Kimmerer (2002) shows a change in delta smelt abundance as it relates to X2 (i.e., flow) historically, the further upstream X2 was the greater the abundance of delta smelt; and more recently, the further upstream X2 the poorer the abundance of delta smelt (see below for additional discussion of X2).

Years of major delta smelt decline have been characterized not only by unusually dry years with exceptionally low outflows (1987-1991) but also by unusually wet years with exceptionally high outflows (1982-83, 1986, 1998). High outflows are believed to flush delta smelt out of the system along with much of the zooplankton. This means that not only is potential spawning

stock of delta smelt reduced, but its food supply as well. Furthermore, depletion of established populations of invertebrates and fish may have made it easier for exotic species of copepods, clams, and fish to colonize the estuary, which may be detrimental to delta smelt (Service 1996).

Years of high delta smelt abundance were strongly correlated with the springtime location and duration of the 2 parts per thousand (ppt) bottom isohaline (X2) demarcation. There is some evidence that a large part of this relationship rests on the number of days in April when salinities of 2 ppt are between Middle Ground and Roe Island. The higher captures of delta smelt below 2 ppt and in shallow habitats (when waters of 2 ppt are near shallow habitats) suggest habitat selection by delta smelt. The tie between the amount of this habitat and fall abundance of delta smelt also suggests that availability of suitable habitat limits the abundance of this species. In the absence of a significant stock/recruitment relationship or tie to any other environmental variable, availability of nursery habitat may be a limiting factor to abundance of adult delta smelt (Service 1996). Future research efforts will hopefully draw more certain conclusions regarding the relationship between physical habitat and population status.

## WATER DIVERSIONS

Water is pumped out of the Delta system mainly by the CVP and SWP to supply California's agriculture and municipal demands (Service 1996). Also, over 1,800 small diversions within the Delta supply water for Delta farms (CDWR 1995). Water is also pumped through power plants for cooling west of the Delta (Service 1996). Delta smelt are caught (entrained) in all these pumping facilities (Service 1996). The early stages of these fish are planktonic and weak swimmers making them susceptible to flow patterns (Service 1996). Large numbers of young delta smelt are entrained at CVP and SWP plants (Service 1996). Efforts are made to rescue a portion of the fish (greater or equal to 20 millimeters (mm) fork length being entrained at CVP and SWP plants by trapping them and trucking them back to the Delta (Service 1996). There are no efforts to rescue or quantify fish below 20 mm, these fish are the most susceptible to entrainment and loss (Service 1996). The effectiveness of the salvage activities have not been well evaluated, however, delta smelt are very fragile and the majority die as a result of the process (Bennett 2003).

During dry years, larvae are concentrated in the river channels making them more likely to be entrained in major and minor diversions. High export pumping in dry years changes the hydraulics of the Delta and small fish are shifted upstream to Delta channels rather than in Suisun Bay where they are relatively immune to entrainment. Studies are currently being conducted to quantify losses of delta smelt and other fishes to these delta diversions. Some delta smelt have been captured in agricultural diversions during the studies, but it appears that season, location and size of the diversion are major factors affecting entrainment of delta smelt. Other major diversions within the habitat of delta smelt are the power generation facilities west of the Delta, near Pittsburg and Antioch. These facilities are believed to entrain large numbers of delta smelt juveniles and larvae. Several million larval and juvenile delta smelt are estimated as lost in State, Federal, agricultural, and cooling diversions each year.

There is consensus among experts that power plants with flow through cooling can impose significant mortality if they are close to fish habitat (CALFED 2003a and Service 1996). In the San Francisco Estuary there are two such plants, one at Pittsburg and one at Antioch, both well within the region of maximum abundance of delta smelt for many months of each year (CALFED 2003a and Service 1996).

The California Department of Fish and Game (CDFG) (2003g) is concerned that entrainment at the CVP and SWP may be a major source of population impacts under certain conditions. The Summer Tow Net Survey data show an almost complete disappearance of juvenile delta smelt in the south delta sampling stations by the mid-1970s (CDFG 2003g). This disappearance followed a trend of increasing combined water exports from the south Delta (CDFG 2003g). They further state that they estimate the losses of delta smelt juveniles to SWP and CVP operations to range between 11 to 46% annually (Kimmerer, pers. comm. as cited in CDFG 2003g).

CDFG (2003g) states that in the pre-decline period, delta smelt were more abundant in the delta and less abundant in Suisun Marsh, and in the post-decline period the delta smelt are now less abundant in the delta and more abundant in Suisun Marsh. CDFG concludes that the water exports since the 1970s removed optimal smelt rearing conditions within the delta (CDFG 2003g).

Based upon years of entrainment data at the CVP and SWP facilities, it is clear that large numbers of delta smelt are subject to mortality each year. However, the net effect of this mortality on the delta smelt population structure is difficult to predict at this time.

The CDWR and the U.S. Bureau of Reclamation (Reclamation) are currently preparing a proposal to replace the temporary barriers with permanent barriers. The change from temporary fish and agricultural barriers to permanent barriers in the South Delta could result in additional effects to delta smelt. The temporary barriers are installed in April of each year and are removed in November, and serve the purpose of maintaining water levels for in-delta diverters. These barriers operate using tidal flap gates, meaning the barriers allow the flood tide flow upstream and then close when the tide ebbs to hold water behind the barriers. These barriers physically prevent smelt movement and can also change delta hydraulics (Service 2001). The proposed permanent barriers operations may include operating during additional periods and may include different operations that may affect delta smelt. Computer simulations by the California Department of Water Resources (2003) have shown that placement of the barriers changes south delta hydrodynamics, increasing central delta flows toward the state and federal export facilities. When delta smelt occur in areas influenced by the barriers, entrainment losses at the state and federal export facilities could increase. However, the operations and effects of the permanent barriers have not yet been fully analyzed.

## PROPOSED MODIFICATIONS TO THE WATER SYSTEM

The demands on surface water resources in the Central Valley have increased. The proposed Freeport Regional Water Project would divert up to 185,000 acre-feet(af)/year of water from a point of diversion north of the delta at Freeport (Freeport Regional Water Authority 2003). The

proposed expansion of Los Vaqueros Reservoir would entail an additional 400,000 af of off-stream storage, diverted from the delta using existing facilities as well as new facilities located at Old River and/or Middle River (CALFED 2003c and Reclamation 2003a). Reclamation and CDWR have proposed to increase pumping capacity at the SWP Banks pumping plant from 6,680 cubic feet per second (cfs) to 8,500 cfs and eventually to 10,300 cfs (CALFED 2002b, 2003d). Reclamation and CDWR have also proposed construction of a 400 cfs intertie connecting their aqueducts, which would allow Reclamation to increase the pumping at their Tracy Pumping Plant from 4,200 cfs to 4,600 cfs. The CALFED Bay-Delta Program proposes to expand surface water storage capacity at existing reservoirs and strategically located off-stream sites by 3.5 million af (including the 400,000 af at Los Vaqueros) by: 1) north of the delta off stream storage; 2) Shasta enlargement; 3) Los Vaqueros Expansion; 4) in-delta storage; and 5) additional storage in the Upper San Joaquin (Friant) (CALFED 2002b and Reclamation 2003a). Finally, the City of Stockton proposes to construct a new intake at the southwestern tip of Empire Tract on the San Joaquin River with an ultimate diversion capacity of 371 cfs (Environmental Science Associates 2003). The diversions would likely result in lower delta outflows and increased entrainment.

In summary, the threats under this category as described in the original listing remain. Since the time of the listing, State and Federal agencies together with stakeholder groups have implemented the Delta's Water Quality Standards, VAMP, and EWA, which have helped to ameliorate these threats. It is unclear how effective these management tools will be over time based on available funding and future demands for water.

**(B) Overutilization for commercial, recreational, scientific or educational purposes**

Our final listing rule (Service 1993) did not identify any threats in this category, and there is no new information concerning threats of overutilization for commercial, recreational, scientific or educational purposes.

**(C) Disease or predation**

Our final listing rule (Service 1993) did not identify any threats in this category.

Antonio *et al.* (2000) examined infections associated with *Mycobacterium* ssp. in wild and captive delta smelt. *Mycobacterium* ssp. was not detected from any of the fish examined immediately after collection from the Sacramento-San Joaquin Estuary or during captivity of broodstock groups at water temperatures of 9-12°C. However, *Mycobacterium* ssp. was isolated from, and mycobacteriosis occurred in, broodstock held at 16°C during spawning season and in experimental groups maintained at 17°C. *Mycobacterium* ssp. and mycobacteriosis were more prevalent among groups frequently handled for physiological experiments. Broodstock groups that were less stressed exhibited a lower prevalence of the bacterium and the disease. Their findings suggest that *Mycobacterium* ssp. may be present in a latent state in the wild population of delta smelt and infections may progress from asymptomatic to clinical under intensive culture conditions. Swanson *et al.* 2002a concluded that while *Mycobacterium* ssp. may not play a significant role in the ecology of delta smelt (e.g. as the proximate cause of post-spawning

mortality), some aspect of the handling of the fish may have caused this disease to develop. The relevance of *Mycobacterium* ssp. to delta smelt in the wild is unknown at this time.

In the central Delta, recent studies by Grimaldo *et al.* (2000) of tidal wetland and marsh habitats show that introduced fishes dominate. The presence of the introduced water plant, *Egeria densa*, appears to be an important factor at sites in the central Delta. In areas where this plant is abundant, native fishes are extremely rare.

Although many species may prey on adult and juvenile delta smelt, much of the attention to date has focused on inland silversides (CALFED 2001). After their accidental introduction to the Delta in 1975, their population expanded rapidly through the 1990s (CALFED 2001). Estimates of abundance of delta smelt and silversides are negatively correlated, suggesting that inland silversides may be an important predator on larval delta smelt and competitor for copepod prey (CALFED 2001). Silversides often occur in dense schools near shorelines and their occurrence may detract from the value of shallow water habitat created to aid delta smelt restoration (CALFED 2001).

As noted by CDWR (2003), however, since the early 1980's there also have been increases in other potential larval fish predators such as coded-wire-tagged chinook salmon smolts released in the delta for survival experiments and non-native centrarchids. In addition, striped bass appear to have switched to piscivorous feeding habits at smaller sizes than they historically did following severe declines in the abundance of mysid shrimp (CDWR 2003). To address concerns regarding delta smelt, the California Department of Fish and Game completed a Habitat Conservation Plan for their striped bass management program, which includes measures designed to help conserve delta smelt.

Northern pike (*Esox lucius*) have been introduced into Lake Davis, and all attempts at eradication have failed (CDFG 2000). If these fish escape into the Sacramento River system and become established in the delta, the delta smelt population will almost certainly be affected (CDFG 2000).

In summary, the threats of disease and predation have still not been sufficiently studied to determine their effects on delta smelt.

### (D) The inadequacy of existing regulatory mechanisms

The operation of the SWP and CVP has been conditioned by the Service's biological opinion (Service 1995). The BO has no provision for the protection of larval delta smelt (<20mm in size) at the facilities. The take is not quantified but assumed to be high in number given the smelt's poor swimming ability. At this time, we do not have information on any correlation or causality between larval delta smelt take and population index.

The discharge of any ballast water into the San Francisco Bay is not prohibited. The U.S. Coast Guard has jurisdiction over ships that discharge ballast water (Service 1996). The Coast Guard requires ships to discharge ballast water before entering U.S. ports, but compliance is voluntary

(Service 1996). A number of non-native species have already been introduced into the Bay-Estuary-Delta from ballast water and without strictly enforced prohibitions on ballast water discharge in the Bay, additional introductions of non-native species can be expected to continue (Service 1996 and Moyle 2003).

### (E) Other natural or manmade factors affecting its continued existence

REDUCED PRODUCTIVITY AND FOOD

Jassby *et al.* (2003) found that phytoplankton biomass has declined over the past few decades, partly because of the Asiatic clam invasion. The phytoplankton decline may represent a reduction in the system's capacity to support higher levels of the food web. Lower phytoplankton levels have been linked to declines in key zooplankton populations in the delta, although the evidence for food limitation of fish populations is not as strong as for zooplankton and benthic invertebrates. However, Kimmerer (2002) pointed out that the decline in delta smelt abundance predates the step decline in the base food web.

Our Recovery Plan (Service 1996) stated that another complicating factor is the rise in abundance of the diatom *Melosira*, at some times to the point where it is the most abundant species of phytoplankton. This diatom grows in long chains and is very difficult for zooplankton to graze on; thus the change in composition and abundance of zooplankton may also be tied to the increased importance of this diatom. The causes of increase in *Melosira* are not known (Service 1996).

GENETICS

Genetic analyses have confirmed that delta smelt and wakasagi (*Hypomesus nipponensis*) are distinct species with delta smelt more closely related to surf smelt than wakasagi (Stanley et al. 1995; Trenham *et al.* 1998). While hybridization is possible between delta smelt and wakasagi the threat of introgression at the population level is believed to be low due to the sterility or lack of viability of offspring (Trenham *et al.* 1998). Interbreeding may cause the loss of valuable gametes of delta smelt and hinder the population from recovering (Moyle 2002, 2003). Swanson *et al.* (2000) studied the temperature, salinity, and flow tolerances of delta smelt and the non native wakasagi, and concluded that delta smelt may be at a physiological disadvantage to wakasagi, particularly in habitats with suboptimal environmental conditions. They also concluded that the low abundance of wakasagi in the delta recorded to date may indicate that factors other than temperature, salinity, and flow determine wakasagi distribution.

Trenham *et al.* 1998 determined that delta smelt exhibits very little population subdivision across its range, and that the delta smelt in the Napa River are not a distinct population.

ENVIRONMENTAL FACTORS

Delta smelt are relatively poor swimmers and show lower swimming ability than other sympatric fishes of the Delta (Swanson *et al.* 2000). Delta smelt are unable to swim against the current for any substantial distance, and therefore are more susceptible to impingement and entrainment at major water diversions than other similar sized fish species (Cech and Swanson 1998; Swanson *et al.* 1998, 2002b, and 2003; Young *et al.* 1998, and 2003; and White *et al.* 1998).

The threats of other natural or manmade factors affecting the delta smelt's continued existence as described in the original listing (Service 1993) remain and will increase. The available information indicates that hybridization with wakasagi is not a threat to delta smelt.

**14. Outcome:**

14.A. Regarding the species' demographic status, does the species now occupy a significant portion of its former range, and within its current range, is the species demographically stable or improving? If not, what is the outlook for expansion of the species into a significant portion of its former range?

The delta smelt currently occupies its historic range; although its abundance in the south delta is considerably lower (CDFG 2003g). Moyle (2002) stated that the pelagic life style, short life span, spawning habits, and relatively low fecundity indicate that a substantial population is necessary to keep delta smelt from becoming extinct.

The two-year running average of the Delta Smelt Recovery Index for 2003, as determined from the FMWT, is the second lowest since the species was listed (Service 2003d). The Summer Tow Net Survey data show an almost complete disappearance of juvenile delta smelt in the south delta sampling stations by the mid-1970s (CDFG 2003g). Moyle (2003), stated that the analysis of 22 years of monthly sampling data from Suisun Marsh shows that the delta smelt have still not recovered to their former abundance, although there has been a general increase in numbers since their low point during a long period of drought (Matern *et al.* 2002)(see appendix B). From these indices, the Service has concluded that the delta smelt abundance has not recovered to its pre-decline (prior to 1982) levels and that the overall trend is negative.

CDFG (2003g) is concerned that entrainment at the CVP and SWP remains be a major source of population impacts under certain conditions, and that the species will remain threatened in the foreseeable future due in part to water exports. Future increases in water exports could increase the population effects to delta smelt. Moyle (2003) states that the delta smelt will never be out of danger of extinction unless there are permanent and reliable changes made to the flow and temperature regimes that favor the smelt.

14.B. What individual threat(s), if any, could result in the extinction of the species within its currently occupied range? What has been done/is being done to abate these threats?

The threats of the destruction, modification, or curtailment of its habitat or range resulting from extreme outflow conditions (reduced outflow or high outflow) and/or the operations of the State and Federal water projects could result in the extinction of the delta smelt (CDFG 2003g and Moyle 2002, 2003). In addition, any one of the many stochastic factors that affect delta smelt, such as predation, invasive species, change in food organisms, toxic substances, disease, competition, and entrainment losses to water diversions can cause their numbers to move towards extinction (Moyle 2002, 2003).

The San Luis & Delta-Mendota Water Authority (2002) submitted to the Secretary of Interior their analysis of population size estimate, population trend and extinction probability for delta smelt. Their analysis was subjected to a peer review by the USGS (2003). The USGS (2003) determined that none of their analysis or assumptions was valid and that their white paper did not constitute new information. Others reviewing their white paper reached the same conclusions as the USGS. (See 9h above)

Moyle (2002) states that it is implicit that the recovery of delta smelt requires the recovery of natural processes in the Sacramento-San Francisco estuary, including outflow. Finding a way to protect the delta smelt without disrupting water supplies (i.e. CVP and SWP operations), was a major reason for the creation of CALFED. The CALFED process set in motion a number of efforts, described in #9D above, toward recovery of delta smelt, although the effectiveness of these measures remains to be seen.

14.C. What combined threats, if any, could result in the extinction of the species within its currently occupied range? What has been done/is being done to abate these threats?

See #14B above.

14.D. If no single threat or combination of threats threatens the species' existence at this time, what single threat or combination of threats could cause a decline toward endangerment?

See #14B above.

FINDING

__X__ The 5-year review does not indicate a change in classification is warranted.

_____ The 5-year review does indicate a change in classification is warranted.

In summary, the threats of the destruction, modification, or curtailment of its habitat or range resulting from extreme outflow conditions, the operations of the State and Federal water projects, and other water diversions as described in the original listing remain. The only new information concerning the delta smelt's population size and extinction probability indicates that the population is at risk of falling below an effective population size and therefore in danger of becoming extinct. Although VAMP and EWA have helped to ameliorate these threats, it is unclear how effective these will continue to be over time based on available funding and future demands for water. In addition, there are increased water demands outside the CVP and SWP which could also impact delta smelt. The increases in water demands are likely to result in less suitable rearing conditions for delta smelt in Suisun Marsh, increased vulnerability to entrainment, and less water available for maintaining the position of X2. The importance of exposure to toxic chemicals on the population of delta smelt is highly uncertain. Therefore, a recommendation to delist the delta smelt is inappropriate.

In addition, many potential threats have not been sufficiently studied to determine their effects, such as predation, disease, competition, and hybridization. Therefore, a recommendation of a change in classification to endangered is premature.

In his August 24, 2003, letter, the foremost delta smelt expert, Dr. Peter B. Moyle, stated that the delta smelt should continue to be listed as a threatened species (Moyle 2003). In addition, in their January 23, 2004, letter, the CDFG fully supported that the delta smelt should retain its threatened status under the Act (CDFG 2004).

**15. If the outcome to #14 above indicated that a change is warranted, recommend the appropriate classification.**

Not Applicable.

**16. List all information and data sources used in this review, and file locations if they will not be filed with the review:** All listed documents are filed within the Sacramento Fish and Wildlife Office.

**A. Peer Reviewed Literature**

Antonio, Dolores B., Christina Swanson, Joseph J. Cech Jr., Randy C. Mager, Sergei Doroshov, and Ronald P. Hedrick. 2000. Prevalence of *Mycobacterium* in Wild and Captive Delta Smelt. California Fish and Game 86(4): 233-243.

Grimaldo, L.F., Peregrin, C., and R. Miller. 2000. Examining the relative predation risks of juvenile chinook salmon in shallow water habitat: the effect of submerged aquatic vegetation. IEP Newsletter, 13(1): 57-61.

Jassby, A.D., J.E. Cloern, and A.B. Muller-Solger. 2003. Phytoplankton fuels Delta food web. California Agriculture, 57(4): 104-109.

Herbold, Bruce. 1994. Habitat Requirements of Delta Smelt. *In*: R. Brown and P. Herrgesell (Eds): Interagency Ecological Studies Program Newsletter, Winter 1994. California Department of Water Resources. Sacramento, California.

Herbold, Bruce. 1996. Why we don't do population estimates for delta smelt. IEP Newsletter, 8(2): 20-22.

Kimmerer, W.J. 2002. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages? Marine Ecological Progress Series 243: 39-55.

Matern, Scott A., Peter B. Moyle, and Leslie C. Pierce. 2002. Native and Alien Fishes in a California Estuarine Marsh: Twenty-One Years of Changing Assemblages. Transactions of the American Fisheries Society 131: 797-816.

Molye, Peter B. 2002. Inland Fishes of California. University of California Press. 576 pp.

Rosenfield, Jonathan A. 2002. Pattern and process in the geographical ranges of freshwater fishes. Global Ecology & Biogeography 11: 323-332.

Stanley, Scott E., Peter B. Moyle, and H. Bradley Shaffer. 1995. Allozyme Analysis of Delta Smelt, *Hypomesus transpacificus* and Longfin Smelt, *Spirinchus thaleichthys* in the Sacramento-San Joaquin Estuary, California. Copeia 2: 390-396.

Stevens, D.E. and L.W. Miller. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin River system. North American Journal of Fisheries Management 3: 425-437.

Swanson, Christina, Paciencia S. Young, and Joseph J. Cech Jr. 1998. Swimming Performance of Delta Smelt: Maximum Performance, and Behavioral and Kinematic Limitations on Swimming at Submaximal Velocities. Great Britian. Journal of Experimantal Biology 201, 333-345.

Swanson, Christina, Turid Reid, Paciencia S. Young, and Joseph J. Cech Jr. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced wakasagi (*H. nipponensis*) in an altered California estuary. Oecologia 123: 384-390.

Swanson, Christina, D.V. Baxa, Paciencia S. Young, Joseph J. Cech Jr., and Ronald P. Hedrick. 2002a. Reduced Swimming Performance in Delta Smelt Infected with *Mycobacterium* ssp. Journal of Fish Biology 61: 1012-1020.

Sweetnam, D.A. and D. E. Stevens. 1993. A status of the delta smelt (*Hypomesus transpacificus*) in California. Report to the Fish and Game Commission. Candidate Species Report 93-DS. 98 pp.

Trenham, Peter C., H. Bradley Shaffer, and Peter B. Moyle. 1998. Biochemical Identification and Assessment of Population Subdivision in Morphologically Similar Native and Invading Smelt Species (*Hypomesus*) on the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society 127: 417-424.

## B. Personal Communications, Comment Letters, White Papers, Workshop Summaries, Federal Register Publications, and All Other Information

Bay Institute, The. 2003. Comment Letter on the Five Year Status Review of the Delta Smelt. 4 pp.

Bennett, William A. 2003. The Population Ecology of Delta Smelt in the San Francisco Estuary. 44 pp.

Bureau of Reclamation. 2003a. Notice of Initiation of Federal Feasibility Studies. Mid-Pacific Regional Office, Sacramento California.

Bureau of Reclamation. 2003b. Draft Long-Term Central Valley Project Operations Criteria and Plan Biological Assessment. Mid-Pacific Regional Office, Sacramento California.

CALFED Bay-Delta Program. 2001. Delta Smelt and CALFED's Environmental Water Account: Summary of a Workshop held September 7, 2001 at the University of California, Davis. Sacramento, California.

CALFED Bay-Delta Program. 2002a. Workshop Summary Water Operations and Environmental Protection in the Delta: Scientific Issues. Sacramento, California.

CALFED Bay-Delta Program. 2002b. Annual Report 2002. Sacramento, California. 80 pp.

CALFED Bay-Delta Program. 2003a. CALFED's Environmental Water Account: Summary of the Annual Delta Smelt Technical Workshop, Santa Cruz, California, August 18-19, 2003. Sacramento, California.

CALFED Bay-Delta Program. 2003b. Ecosystem Restoration Program Project Evaluation Phase 2 Report. Sacramento, California. 72 pp.

CALFED Bay-Delta Program. 2003c. CALFED Los Vaqueros Reservoir Studies [database on the internet]. Updated on May 27, 2003. Available from http://www.lvstudies.com/default.asp. Accessed on October 10, 2003.

CALFED Bay-Delta Program. 2003d. CALFED Implementation: The Role of the Napa Proposal. Powerpoint Presentation. Sacramento, California.

California Department of Fish and Game. 2000. Risk to California's Fisheries [database on the internet]. Available from http://www.dfg.ca.gov/northernpike/mgpike.htm. Accessed on February 6, 2004.

California Department of Fish and Game. 2003a. Fall Midwater Survey Results [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/mwt/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003b. Fish Salvage Monitoring [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/salvage/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003c. Summer Townet Survey [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/townet/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003d. 20mm Survey [database on the internet]. Available from http://www.delta.ca.gov/data/20mm/2000/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003e. Spring Kodiak Trawl [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/skt/. Accessed on October 10, 2003.

California Department of Fish and Game. 2003f. North Bay Aqueduct Larval Fish Survey [database on the internet]. Available from http://www.delta.dfg.ca.gov/data/nba/catchsummary.asp. Accessed on October 10, 2003.

California Department of Fish and Game. 2003g. Comment Letter on the Five Year Status Review of the Delta Smelt. 6 pp.

California Department of Fish and Game. 2004. Comment Letter on the Five Year Status Review of the Delta Smelt. 2 pp.

California Department of Water Resources. 1995. Sacramento San Joaquin Delta Atlas.

California Department of Water Resources. 2003. Comment Letter on the Five Year Status

Review of the Delta Smelt. 20 pp.

Cech, Joseph J. Jr., and Christina Swanson. 1998. Delta Smelt Environmental Requirements and Tolerance Limits. *In*: Proceedings of the Third Delta Smelt Workshop, Sacramento, California.

Environmental Science Associates. 2003. Stockton Delta Water Supply Project. 25 pp.

Freeport Regional Water Authority. 2003. Draft Environmental Impact Report/Environmental Impact Statement.

Interagency Ecological Program. 1996. Striped Bass Egg and Larval Survey [database on the internet]. Updated March 14, 1996. Available from http://www.iep.water.ca.gov/strip_bass_els/.

Knowles, Noah. 2001. Long-Term Inflow and Salinity Changes. *In*: State of the Estuary 2001 Conference. California.

Moyle, Peter B. 2003. Comment Letter on the Five Year Status Review of the Delta Smelt. 4pp.

Rosenfield, Jonathan A. 2003. Comment Letter on the Five Year Status Review of the Delta Smelt. 3 pp.

San Luis & Delta-Mendota Water Authority. 2002. The Delta Smelt and the State of the Science. 5 pp + Appendices.

Swanson, Christina, Paciencia S. Young, Stephanie Chun, Trilia Chen, Teresa MacColl, Leslie Kanemoto, Timothy Mussen, Rachel Kussow, and Joseph J. Cech Jr. 2002b. Close Encounters with a Fish Screen II: The Emerging Delta Smelt Story. *In*: Proceedings of the Symposium and 36th Annual Meeting of the California-Nevada Chapter of the American Fisheries Society. Tahoe City, California.

Swanson, Christina, Paciencia S. Young, Stephanie Chun, Trilia Chen, Timothy Mussen, Joseph J. Cech Jr., G. Aasen, and Robert Fujimura. 2003. Close Encounters with a Fish Screen: Exploring Applications of Laboratory Studies for Developing Fish Screen Criteria for Delta Smelt. *In*: Proceedings of the CALFED Science Conference 2003. Sacramento, California.

U.S. Army Corps of Engineers, Sacramento District. 2002. Napa River Fisheries Monitoring Program Annual Report 2001. Contract # DACW05-01-C-0015. Prepared by: Stillwater Sciences and Jones & Stokes.

U.S. Army Corps of Engineers, Sacramento District. 2003. Napa River Fisheries Monitoring

Program Annual Report 2002. Contract # DACW05-01-C-0015. Prepared by: Stillwater Sciences and Jones & Stokes.

U.S. Fish and Wildlife Service. 1993. Endangered and threatened wildlife and plants: Determination of threatened status for the delta smelt. March 5, 1993. **Federal Register** 58(42): 12854-12864.

U.S. Fish and Wildlife Service. 1994. Endangered and threatened wildlife and plants: Critical habitat determination for the delta smelt. December 19, 1994. **Federal Register** 59(242): 65256-65279.

U.S. Fish and Wildlife Service. 1995. Formal Consultation and Conference on Effects of Long-Term Operation of the Central Valley Project and the State Water Project on the Threatened Delta Smelt, Delta Smelt Critical Habitat, and Proposed Threatened Sacramento Splittail.

U.S. Fish and Wildlife Service. 1996. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. Portland, Oregon. 195 pages.

U.S. Fish and Wildlife Service. 2001. Formal Section 7 Consultation on the South Delta Temporary Barriers Project in San Joaquin County, California. Sacramento, California. 31 pages.

U.S. Fish and Wildlife Service. 2003a. 2003 Species Status as reported to Congress in the Biennial Report. Sacramento Fish and Wildlife Office. Sacramento, California.

U.S. Fish and Wildlife Service. 2003b. Combined Facilities Take Comparison by Month and Water Year type. Sacramento Fish and Wildlife Office. Sacramento, California.

U.S. Fish and Wildlife Service. 2003c. Environmental Water Account Expenditures for Protection of the Delta Smelt in Water Year 2003.

U.S. Fish and Wildlife Service. 2003d. Delta Smelt Recovery Index. Sacramento, California.

USGS. 2003. Editor's Comments-Peer Review of the 2002 San Luis and Delta-Mendota Water Authority White Paper "The Delta Smelt and the State of the Science"

White, D.K., Christina Swanson, Paciencia S. Young, Joseph J. Cech, Jr., and L. Kavvas. 2003. Close Encounters with a Fish Screen: Anatomy of an Impingement. *In*: Proceedings of the CALFED Science Conference 2003. Sacramento, California.

Young, Paciencia S., Christina Swanson, and Joseph J. Cech, Jr. 1998. Delta Smelt Swimming Performance: Effects of Environmental Variables. *In:* Proceedings of the Third Delta Smelt Workshop, Sacramento, California.

Young, Paciencia S., Christina Swanson, Leslie Kanemoto, Trilia Chen, Stephanie Chun, Joseph J. Cech, Jr., Z.Q. Chen, H. Bandeh, and L. Kavvas. 2003. Close Encounters with Two Fish Screens: Responses of Delta Fishes to Simulated Multiple Exposures. *In*: Proceedings of the CALFED Science Conference 2003. Sacramento, California.

### C. Literature from the Listing File

Bailey, H.C., D.J. Ostrach, and D.E. Hinton. 1991. Effect of rice irrigation water in Colusa Basin Drain on fertilization success and embryonic development in striped bass. Contract No. 9-169-250-0 Draft Report to California State Water Resources Control Board. 31 pp.

California Department of Water Resources. 1992. Data and computations used to determine 1993 water charges. Bulletin 132-92, Appendix B. California Department of Water Resources, Sacramento, California. 136 pp.

California State Water Resources Control Board. 1992. Draft Water Right Decision 1630, San Francisco Bay/Sacramento-San Joaquin Delta Estuary, December 1992. State Water Resources Control Board, Sacramento, California. 121 pp. + Appendices.

Carlton, J.T., J.K. Thompson, L.E. Schemel, and F.H. Nichols. 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis*. I. Introduction and dispersal. Mar. Ecol. Prog. Ser. 66: 81-94.

Houde, E.D. 1989. Comparative growth, mortality, and energetics of marine fish larvae: Temperature and implied latitudinal effects. Fishery Bulletin, U.S. 87: 471-495.

Lorentzen, E.M. 1987. U.S. Fish and Wildlife Service testimony in the matter of State Water Resources Control Board water quality/water rights proceeding on the San Francisco Bay and Sacramento-San Joaquin River Delta, September 8-10, 1987. U.S. Fish Wildlife Service Exhibits 17-24. 11 pp.

Morat, R.J. 1991. U.S. Fish and Wildlife Service testimony in the matter of State Water Resources Control Board Public Hearing and Board Meeting on consideration of drought-related emergency water rights order and related actions in response to a request for a hearing from the Department of Water Resources, March 15, 1991. U.S. Fish Wildlife Service Exhibit 1. 3 pp.

Moyle, P.B. 1976. Inland Fishes of California. University of California Press, Berkeley, California. 405 pp.

Moyle, P.B. and B. Herbold. 1989. Status of the delta smelt, *Hypomesus transpacificus*. Unpublished final report prepared for U.S. Fish and Wildlife Service, Sacramento Field Office, Habitat Conservation Division, Sacramento, California. 42 pp.

Moyle, P.B., B. Herbold, D.E. Stevens, and L.W. Miller. 1992. Life history and status of delta smelt in the Sacramento-San Joaquin Estuary, California. Trans. Amer. Fish. Soc. 121: 67-77.

Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Final report prepared for State of California, Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California. 222 pp.

Nichols, F.H., J.E. Cloern, S.N. Luoma, and D.H. Peterson. 1986. The modification of an estuary. Science 231: 567-573.

Radtke, L.D. 1966. Distribution of smelt, juvenile sturgeon, and starry flounder in the Sacramento-San Joaquin Delta. Pp. 115-119 *In*: J.L. Turner and D.W. Kelley, eds.: Ecological studies of the Sacramento-San Joaquin estuary, Part 2. California Department of Fish and Game Fish Bulletin No. 136.

Shepherd, J.G. and D.H. Cushing. 1980. A mechanism for density-dependent survival of larval fish as the basis of a stock recruitment relationship. J. Cons. int. Explor. Mer 39: 160-167.

Stevens, D.E., L.W. Miller, and B.C. Bolster. 1990. Report to the Fish and Game Commission: A status review of the delta smelt (*Hypomesus transpacificus*) in California. California Department of Fish and Game Candidate Species Status Report 90-2. 149 pp.

Sweetnam, D. 1992. Delta Smelt Project Update, October 1992. Unpublished report prepared by California Department of Fish and Game, Bay-Delta and Special Water Projects Division, Stockton, California. 7 pp.

**17. List all knowledgeable experts and their affiliations used in this review:**

The Service received comments from individuals and agencies during our comment period (see Appendix C for a list of commentors). In addition, the Service closely worked with CDFG to coordinate with their review on the status of delta smelt. In their January 23, 2004, letter, CDFG fully supported that the delta smelt should retain its threatened status under the Act.

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW
SIGNATURE PAGE

Species: *Hypomesus transpacificus*

Recommendation: *No change in listing status.*

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve _____/Date 3/31/04

Do not Approve_____/Date

*Lead Field Offices must ensure that all other Field Offices within the range of the species' have been provided an adequate opportunity to review and comment prior to the reviews' completion. For all species where a change in classification is recommended, written concurrence from other Field Offices is required.*

Cooperating Field Supervisor, U.S. Fish and Wildlife Service

Concur N/A /Date

Not concur_____/Date

Lead Regional Director, U.S. Fish and Wildlife Service

Concur _____/Date 3/31/2004

Not concur_____/Date

*The Regional Director must sign all 5-year reviews, unless the authority has been delegated by the Regional Director to the Field Supervisor.*

Cooperating Regional Director, U.S. Fish and Wildlife Service

Concur _____/Date

Not concur_____/Date

*The Lead Region must ensure that any other Regions within the range of the species' have been provided an adequate opportunity to review and comment prior to the reviews' completion. For all species where a change in classification is recommended, written concurrence from other Regional Directors is required.*

## APPENDIX A
## to the 5-year review for
## *Hypomesus transpacificus* (delta smelt)

Based upon our review of the best available scientific data, we concluded that the delta smelt should retain threatened status. Many of the original threats to delta smelt identified in the 1993 listing continue to exist, and the population of delta smelt remains substantially below its historical levels. While some important improvements have been made, most threats which were discussed in the original listing remain. Therefore, it is not justified at this time to recommend delisting of the delta smelt.

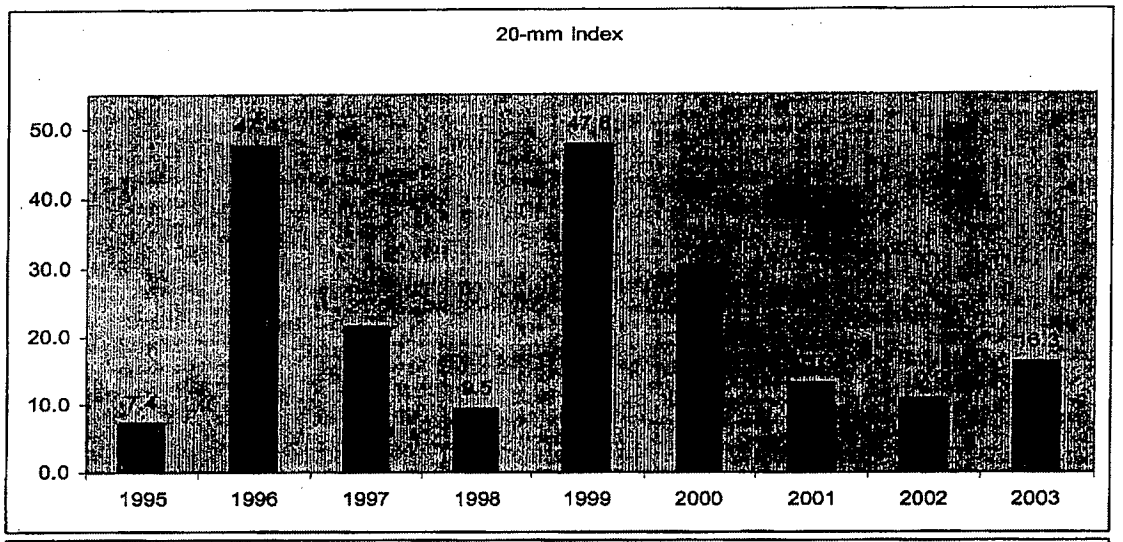
Having reached this conclusion, we nevertheless acknowledge that the San Luis & Delta-Mendota Water Authority's white paper made several important points with which we agree:

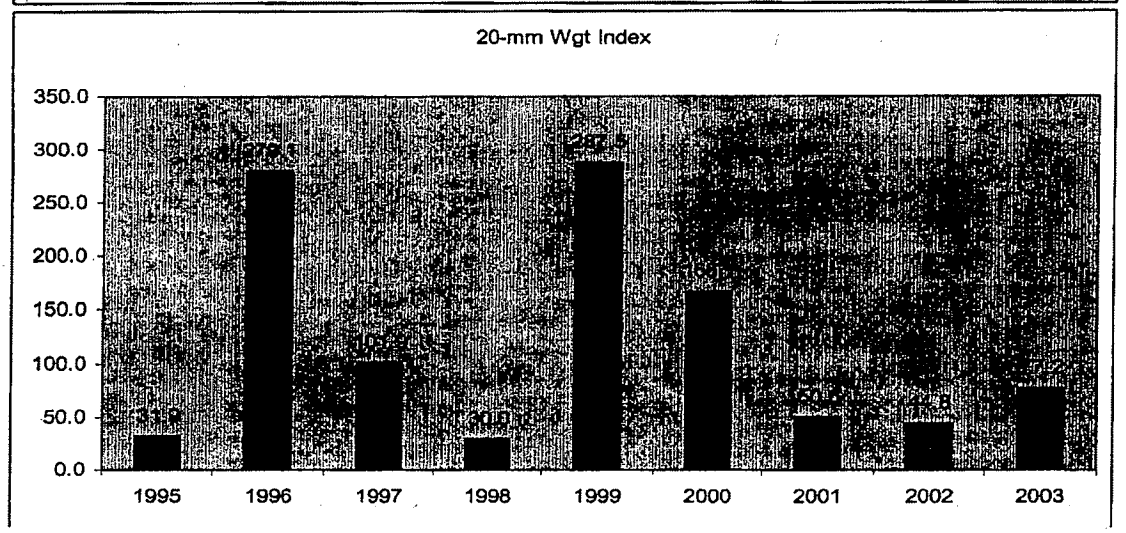
- Since 1996, significant new information has been collected, and therefore some of the original recovery criteria are outdated and in need of revision.
- Some of the data collection and analysis methods are not well suited for monitoring delta smelt abundance or population trends and should be improved.
- The Service should work more closely with you and other interested parties to incorporate updated scientific information into water management decisions.

There has been substantial information gathered since the time of listing concerning the life history and biology of delta smelt. Since the recovery plan was written in 1996 our understanding of how the delta smelt respond over time to changes in environmental conditions does not seem to have been born out. Dr. Peter Moyle (former Delta Native Fishes Recovery Team Leader) in his comments on the notice for this review (Moyle, 2003) suggested that the current numerical criteria for delta smelt are no longer appropriate based on our current understanding of delta smelt biology. Although the numeric criteria in the 1996 recovery plan have been met, it appears that the long-term trend of delta smelt abundance indices has not appreciably changed since the time of listing. There is numerous new data collection and analytical methods that have been explored in order to better understand delta smelt population dynamics these include the 20 mm survey and the spring townet survey. Also analytical methods to try and correlate different data sets for a more predictive estimate of future abundance have been investigated such as relationships between summer tow-net surveys and the fall mid-water trawl. The high degree of variability in the population both in time and space do not appear to be accurately reflected in the current numeric criteria. That is to say the current criteria only use one data set (fall mid-water trawl) and only a sub-set of the data set. There are geographic limitations to the data set in terms of establishing recovery over the known range of the species. The role of environmental variables such as the role of hydrology and climactic conditions in delta smelt population dynamics is not well understood and the temporal nature of the current recovery criteria should be reviewed. Based on the above reasoning and recommendations from experts in the field we recommend that a recovery team be reconvened to review the biology of delta smelt and revise the numeric criteria as appropriate.

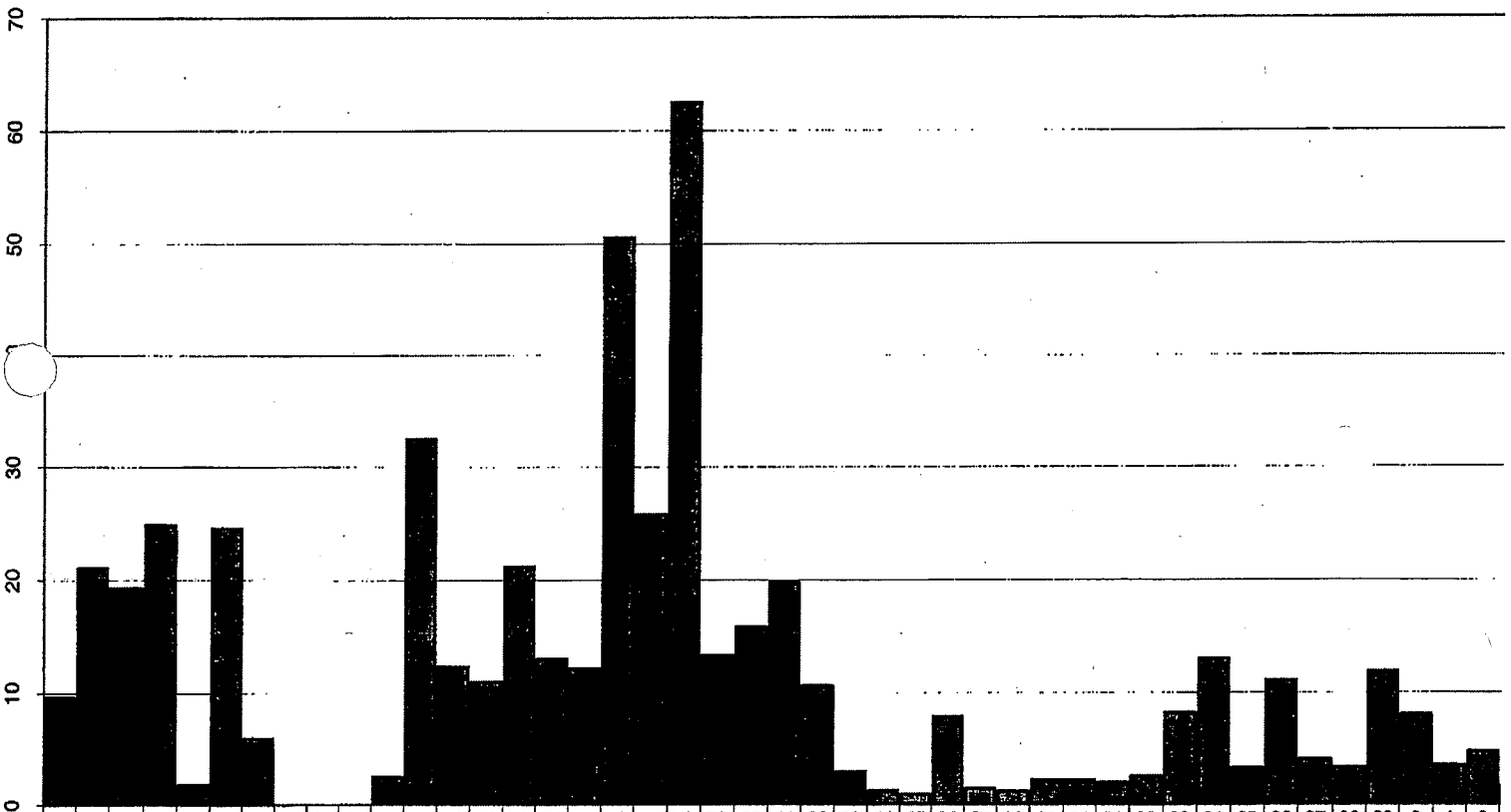
**APPENDIX B**
**to the 5-year review for**
***Hypomesus transpacificus* (delta smelt)**
**Date**

Abundance Index Tables

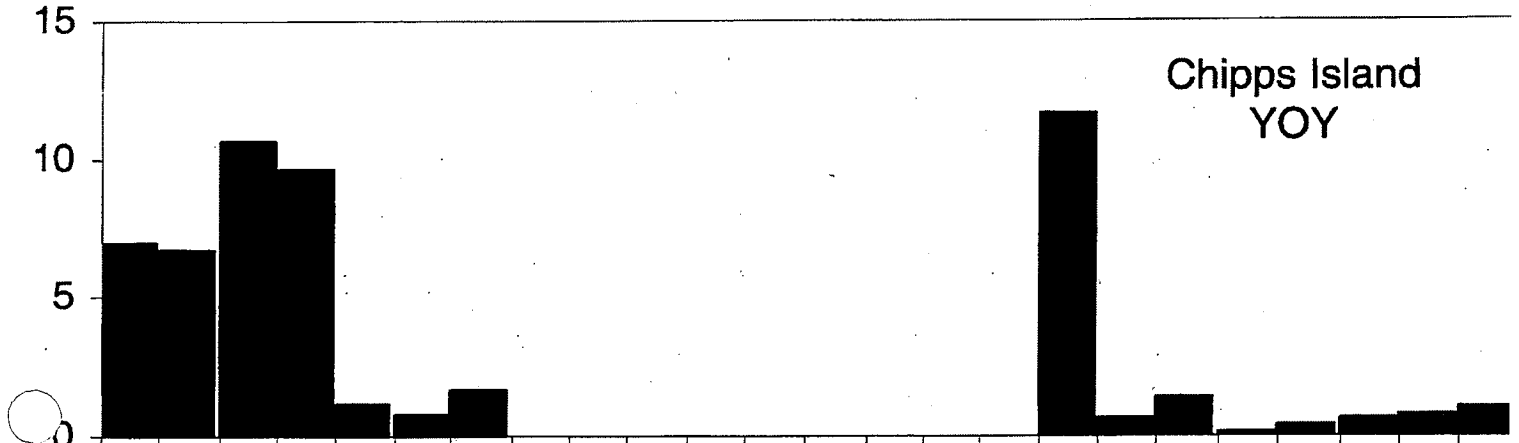

20-mm Index
50.0
40.0
30.0
20.0
10.0
0.0
1995
1996
1997
1998
1999
2000
2001
2002
2003


20-mm Wgt Index
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1995
1996
1997
1998
1999
2000
2001
2002
2003

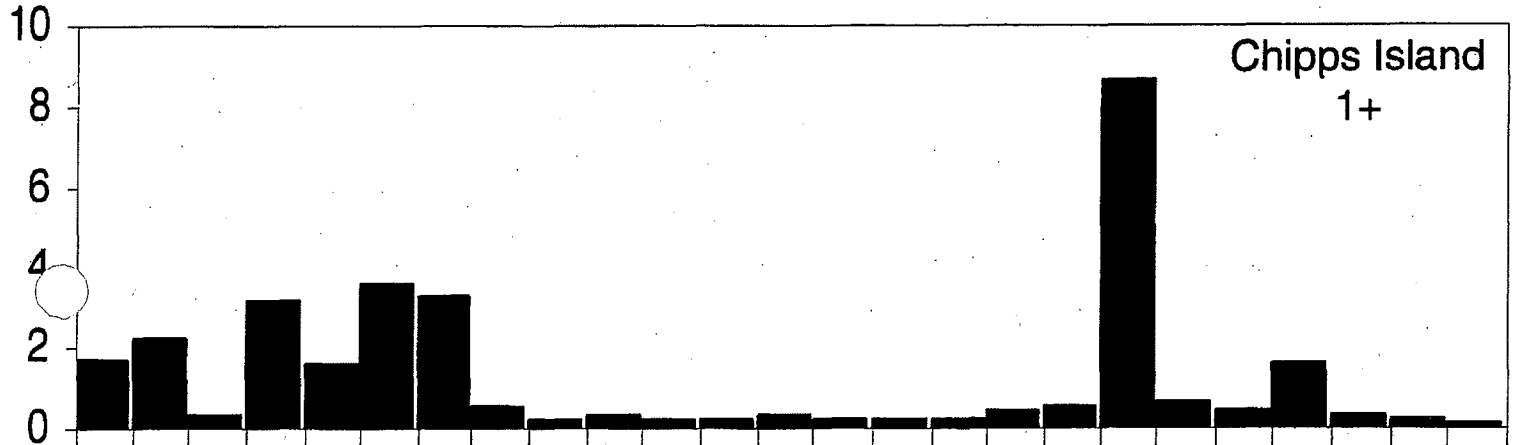
TNS Index




| | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 0 | 1 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Index | 9.6 | 21 | 19 | 25 | 1.8 | 25 | 6 | | | | 2.5 | 33 | 12 | 11 | 21 | 13 | 12 | 51 | 26 | 63 | 13 | 16 | 20 | 11 | 2.9 | 1.2 | 0.9 | 7.8 | 1.4 | 1.2 | 2.2 | 2.2 | 2 | 2.5 | 8.2 | 13 | 3.2 | 11 | 4 | 3.3 | 12 | 8 | 3.5 | 4.7 |

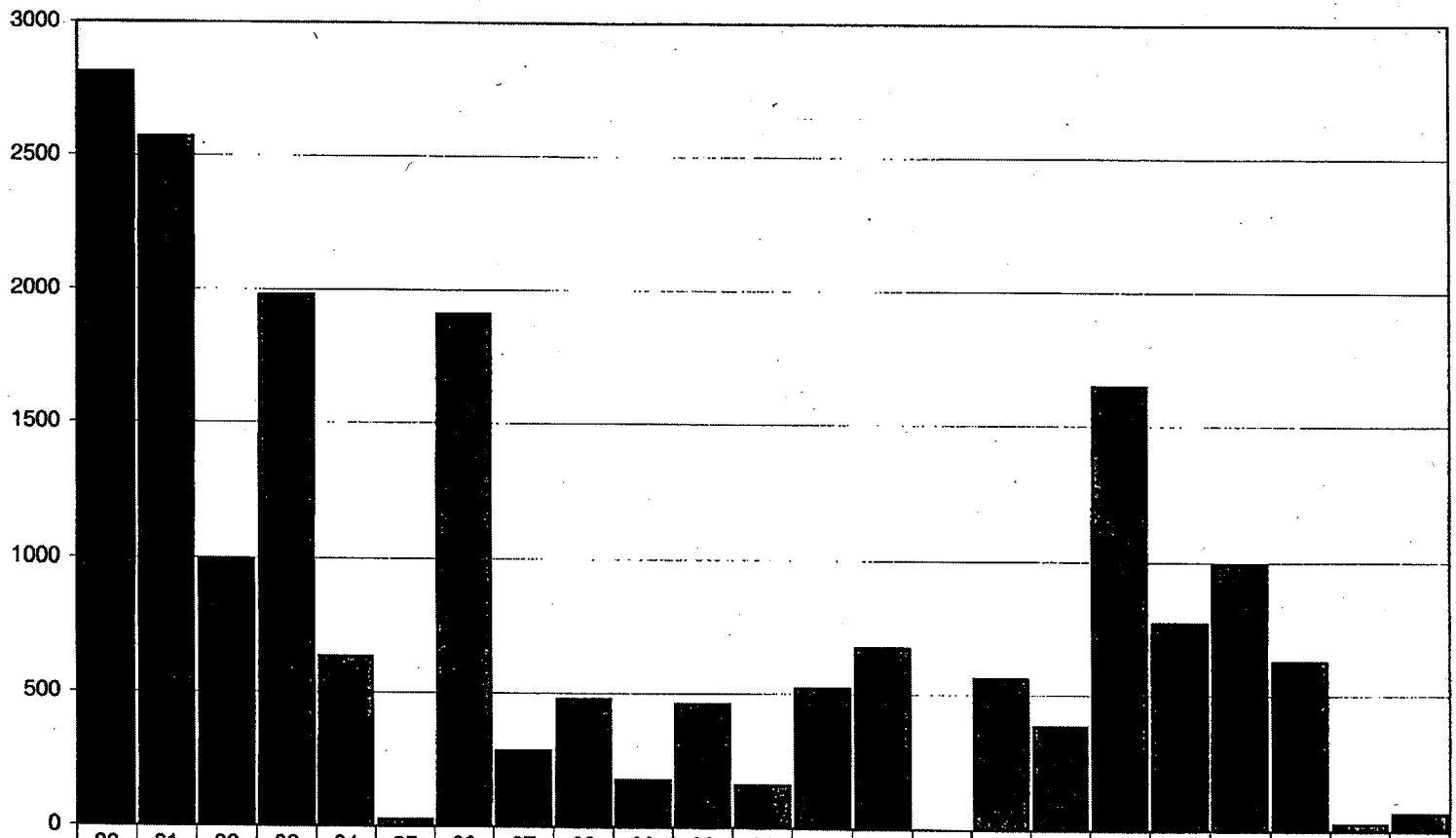



| | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Index | 6.883 | 6.733 | 10.6 | 9.57 | 1.153 | 0.791 | 1.592 | 0 | 0.036 | 0 | 0.006 | 0.034 | 0.061 | 0.004 | 0 | 0.058 | 11.58 | 0.654 | 1.346 | 0.138 | 0.372 | 0.57 | 0.758 | 0.999 |



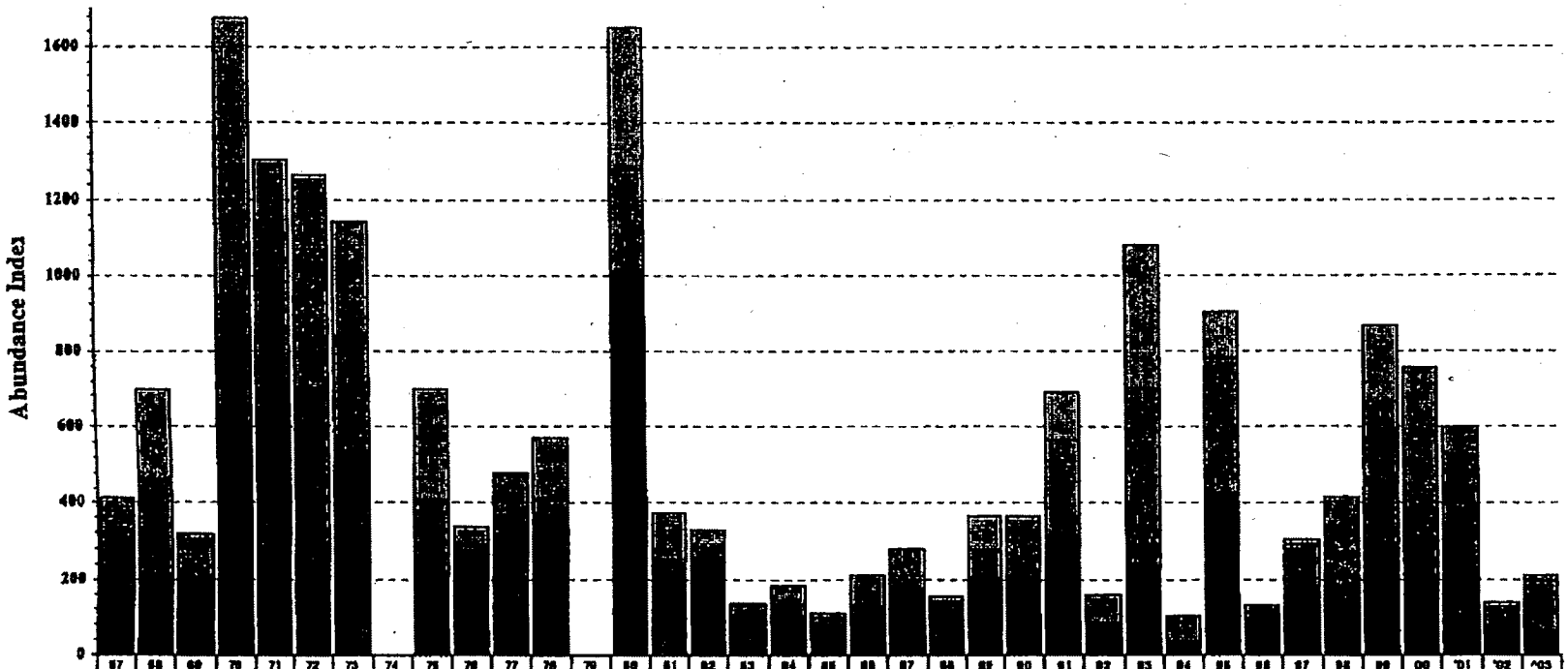

| | 1978 | 1979 | 1980 | 1981 | 1982 | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Index | 1.642 | 2.214 | 0.356 | 3.11 | 1.611 | 3.579 | 3.286 | 0.576 | 0.218 | 0.337 | 0.187 | 0.205 | 0.285 | 0.164 | 0.239 | 0.235 | 0.408 | 0.503 | 8.61 | 0.633 | 0.372 | 1.612 | 0.358 | 0.223 | 0.152 |

## Bay Study Delta Smelt YOY Index



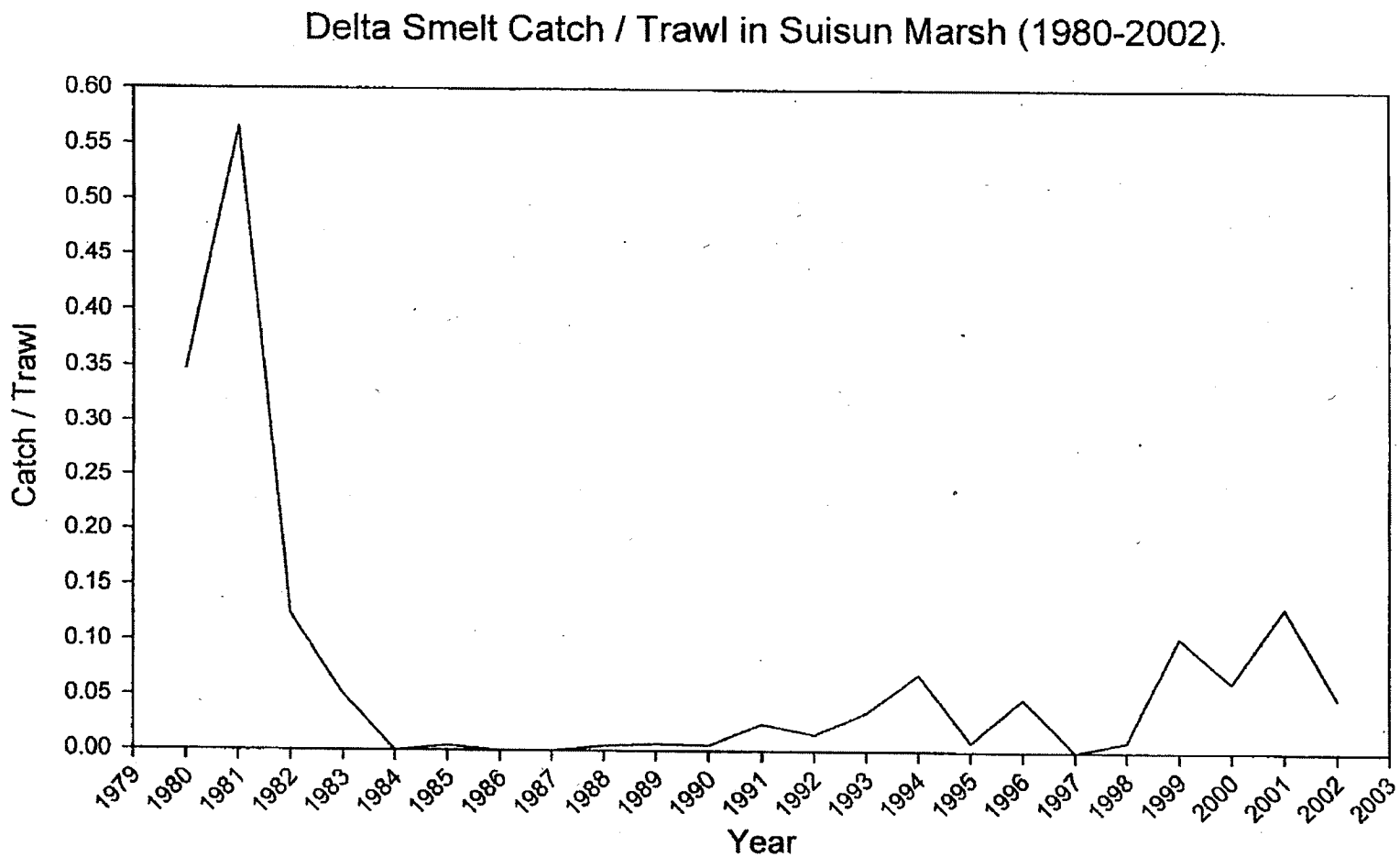

| | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 0 | 1 | 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Series1 | 2813 | 2568 | 996 | 1979 | 636 | 24 | 1909 | 283 | 476 | 176 | 459 | 161 | 522 | 676 | | 564 | 382 | 1647 | 773 | 993 | 630 | 27 | 63 |

# Delta Smelt Fall Midwater Trawl Abundance Index

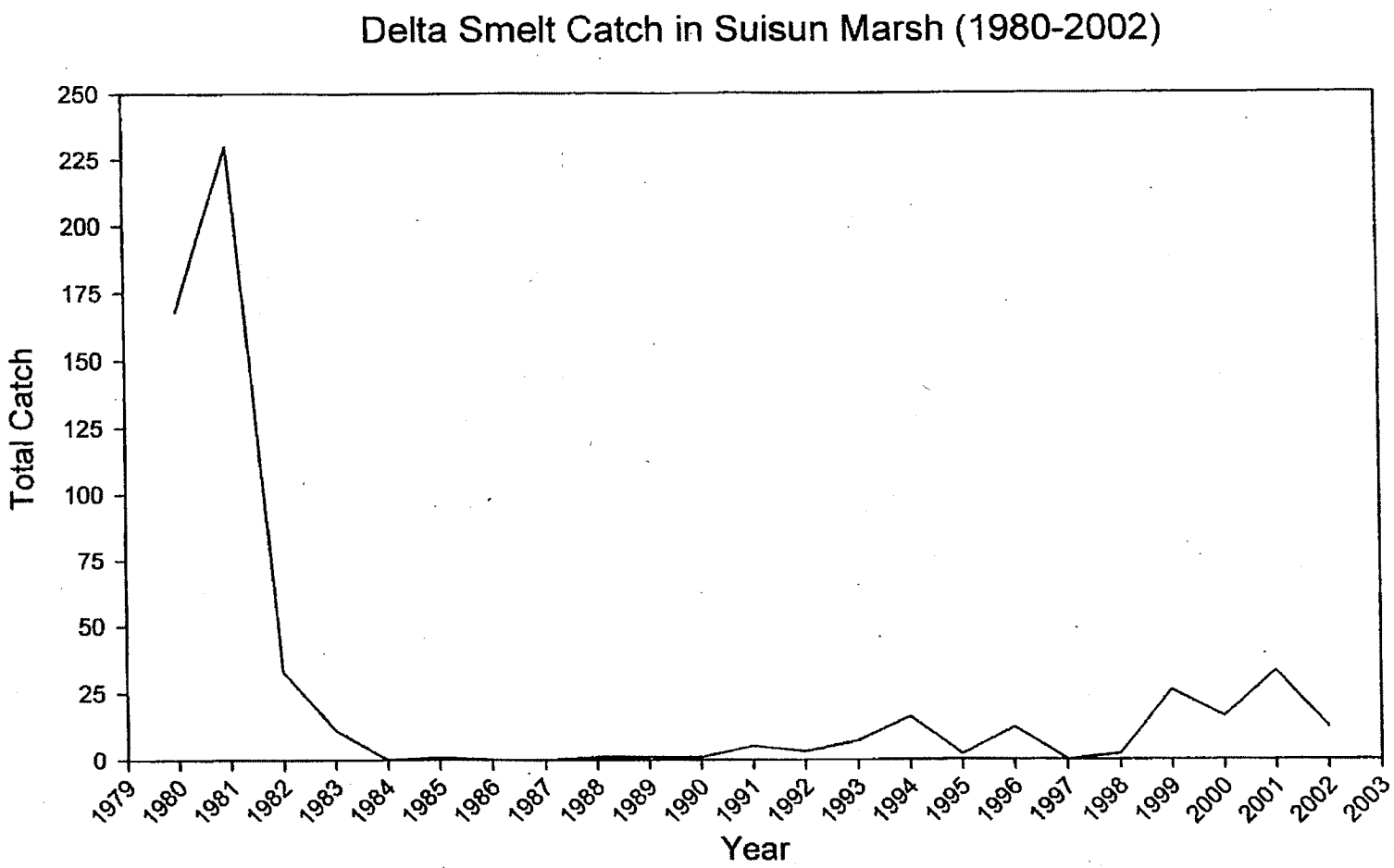



| | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | '01 | '02 | ^03 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Index | 414.9 | 698.5 | 318.0 | 1677.6 | 1308.2 | 1267.0 | 1148.9 | | 697.9 | 337.8 | 479.8 | 571.6 | | 1651 | 376 | 330.2 | 132.3 | 181.5 | 109.2 | 211.9 | 280.2 | 152.6 | 366.2 | 363.4 | 689.1 | 156.8 | 1079 | 101.2 | 898.7 | 128.3 | 306.6 | 417.6 | 863.5 | 683 | 603 | 139 | 210 |
| Sep | 93.4 | 234.7 | 149.8 | 741.6 | 197.4 | 571.6 | 307.8 | | 290.5 | 49.8 | 97.5 | 188.8 | | 368.8 | 122.4 | 44.8 | 2.1 | 47.0 | 40.7 | 92.1 | 71.0 | 41.6 | 88.1 | 106.8 | 125.9 | 71.6 | 375.7 | 64.8 | 120.4 | 20.5 | 14.6 | 238.0 | 197.9 | 428.7 | 75.4 | 20 | 14.7 |
| Oct | 165.2 | 253.4 | 78.8 | 343.0 | 473.1 | 472.0 | 312.4 | | 213.7 | 42.2 | 242.5 | 84.7 | | 273.7 | 27.3 | 47.4 | 26.0 | 43.7 | 23.8 | 15.1 | 39.6 | 67.0 | 74.7 | 49.7 | 249.2 | 3.5 | 470.0 | 11.9 | 349.8 | 23.0 | 112.9 | 94.7 | 380.2 | 129.9 | 479.7 | 48 | 136 |
| Nov | 31.1 | 110.8 | 85.3 | 83.1 | 427.7 | 81.1 | 198.2 | | 102.3 | 120.9 | 81.7 | 31.1 | | 806.2 | 84.2 | 78.0 | 77.9 | 96.5 | 26.0 | 33.8 | 89.5 | 18.1 | 157.0 | 187.5 | 279.0 | 57.5 | 94.3 | 6.5 | 350.6 | 13.1 | 70.1 | 14.8 | 113.7 | 86.2 | 18.1 | 29 | 17 |
| Dec | 125.2 | 88.7 | 33.7 | 509.9 | 207.7 | 142.3 | 327.4 | | 81.3 | 126.0 | 87.5 | 308.9 | | 422.9 | 181.1 | 162.0 | 24.3 | 24.2 | 18.9 | 70.9 | 100.1 | 24.8 | 45.6 | 15.6 | 35.0 | 24.3 | 139.4 | 17.8 | 78.1 | 71.6 | 106.0 | 70.1 | 171.7 | 142.1 | 30 | 44 | 42 |

Year




Data from Peter B. Moyle, Suisun Marsh study




Data from Peter B. Moyle, Suisun Marsh study

**APPENDIX C**
**to the 5-year review for**
***Hypomesus transpacificus* (delta smelt)**
**Date**

Commentors Index

| Name | Address | Description |
|---|---|---|
| Dr. Peter B. Moyle, Ph.D., Professor | Department of Wildlife, Fish, and Conservation Biology<br>University California at Davis<br>1 Shields Avenue<br>Davis, CA 95616-8751 | 38pages<br>includes letter, 3 journal articles co-authored by commenter, and 2 graphs; **"Moyle 2002" cited** [Inland Fishes of California] |
| Dr. Jonathan A. Rosenfield, Ph.D.<br>Post-Graduate Researcher | Center for Integrated Watershed Science and Management<br>1 Shields Avenue<br>University California at Davis<br>Davis, CA 95616-8751 | 13 pages<br>includes letter, journal article by commenter, and list of references |
| Mr. Perry L. Herrgesell, Chief | Central Valley-Bay Delta Branch<br>California Department of Fish and Game<br>4001 N. Wilson Way<br>Stockton, CA 94205-2486 | 6 pages<br>includes letter, 2 cites, data, and graphs |
| Dr. Joe J. Cech, Jr.<br>Professor | Department of Wildlife, Fish, and Conservation Biology<br>University California at Davis<br>1 Shields Avenue<br>Davis, CA 95616-8751 | 50 pages<br>includes 7 abstracts & 4 journal articles |
| Mr. Stephen W. Verigin, Acting Chief Deputy Director | Division of Environmental Services<br>California Department of Water Resources<br>3251 S Street<br>Sacramento, CA 95816-7017 | 20 pages<br>includes letter |
| Dr. Christina Swanson, Ph.D.,<br>Senior Scientist | The Bay Institute<br>500 Palm Drive, Suite 200<br>Novato, CA 94949-5006 | 4 pages |
| Ms. Florence LaRiviere, Chair | Citizens Committee to Complete the Refuge<br>453 Tennessee Lane<br>Palo Alto, CA 94306-4149 | 4 pages<br>1 citation |
| Mr. Bill Pauli, President | Farm Bureau Federation<br>2300 River Plaza Drive<br>Sacramento, CA 95833-3239 | 10 attachments = 1 1/8"<br><br>2 copies |
| Mr. Daniel J. O'Hanlon, Attorney At Law | Kronick, Moskovitz, Tiedemann, & Girard<br>400 Capitol Mall, 27th Floor | comments by water contractors<br>2 ½" |

Attachment 19

# FALL-RUN CHINOOK SALMON SPAWNER POPULATIONS

SACRAMENTO RIVER SYSTEM : Keswick Dam to Red Bluff Diversion Dam (RBDD)

| YEAR | Sacramento River Mainstem: In-river | Sacramento River Mainstem: Transfer to CNFH 1/ | Sacramento River Mainstem: TOTAL | Battle Creek: CNFH | Battle Creek: In-river Dnst. CNFH | Battle Creek: In-river Upst. CNFH 2/ | Battle Creek: TOTAL | Clear Creek | Spring Gulch | China Gl. | Olney Cr. | Cotton-wood Cr. | Paynes Cr. | Cow Cr. | Bear Cr. | Ash Cr. | Still-water Cr. | Inks Cr. | Other 3/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1952 | a/ | 7,000 | 7,000 | 11,000 | 4,000 | | 15,000 | | | | | | | | | | | | |
| 1953 | a/ | 8,000 | 8,000 | 12,000 | 4,000 | | 16,000 | 1,500 | | | | 3,000 | | 3,000 | 800 | | | | |
| 1954 | a/ | 6,000 | 6,000 | 8,000 | 4,000 | | 12,000 | 3,000 | | | | 1,000 | | 4,500 | 500 | | | | |
| 1955 | a/ | 6,000 | 6,000 | 10,000 | 16,000 | | 26,000 | 500 | | | | 800 | | 1,300 | 200 | | | | |
| 1956 | 84,716 | 2,641 | 87,357 | 7,458 | 13,650 | | 21,108 | 2,650 | 950 | 385 | | 660 | | 3,200 | 5 | | | | |
| 1957 | 47,300 | 7,689 | 54,989 | 3,045 | 2,285 | | 5,330 | 330 | | | | 358 | | 700 | 30 | 10 | 140 | | |
| 1958 | 99,300 | 7,853 | 107,153 | 14,643 | 14,500 | 100 | 29,243 | 1,600 | | 200 | 30 | 600 | | 3,300 | 200 | | | | |
| 1959 | 249,600 | 7,100 | 256,700 | 10,833 | 19,300 | 100 | 30,233 | 775 | 955 | | | 3,300 | | 680 | 10 | | | | |
| 1960 | 210,000 | 8,940 | 218,940 | 9,605 | 14,200 | | 23,805 | 900 | | | | 350 | | 650 | 50 | 10 | | | |
| 1961 | 134,700 | 5,481 | 140,181 | 8,156 | 11,700 | | 19,856 | | | | | 1,500 | | | | | | | |
| 1962 | 115,500 | 12,337 | 127,837 | 4,857 | 8,200 | | 13,057 | 5,400 | | | | 6,000 | | 1,500 | | | | | |
| 1963 | 135,200 | 3,681 | 138,881 | 5,114 | 12,400 | | 17,514 | 10,000 | | | | 3,500 | | | | | | | |
| 1964 | 140,500 | 2,084 | 142,584 | 3,875 | 12,000 | | 15,875 | 2,500 | | | | 3,450 | | 1,000 | 50 | | | | |
| 1965 | 98,900 | 2,976 | 101,876 | 3,194 | 6,000 | | 9,194 | 2,500 | | | | 900 | 35 | 1,000 | 350 | | | | |
| 1966 | 107,900 | 3,981 | 111,881 | 900 | 2,400 | | 3,300 | 900 | | | | 2,900 | 300 | 7,600 | 400 | | | | |
| 1967 | 78,100 | 4,390 | 82,490 | 3,050 | 2,160 | | 5,210 | 370 | | | | 600 | | 520 | 30 | | | | |
| 1968 | 95,600 | 2,829 | 98,429 | 3,526 | 2,950 | | 6,476 | 800 | | | | 8,540 | | 7,540 | 310 | | | | |
| 1969 | 114,600 | 1,052 | 115,652 | 2,626 | 3,200 | | 5,826 | 1,240 | | | | 4,967 | 300 | 5,570 | 560 | 320 | 150 | 230 | |
| 1970 | 62,298 | 2,844 | 65,142 | 3,512 | 3,320 | | 6,832 | | | | | | | | | | | | 5,308 |
| 1971 | 52,247 | 1,641 | 53,888 | 2,004 | 3,285 | | 5,289 | | | | | | | | | | | | |
| 1972 | 33,559 | 399 | 33,958 | 2,822 | 2,030 | | 4,852 | | | | | | | | | | | | |
| 1973 | 40,424 | 705 | 41,129 | 3,835 | 4,300 | | 8,135 | | | | | | | | | | | | |
| 1974 | 45,590 | 1,429 | 47,019 | 1,607 | 2,294 | | 3,901 | | | | | | | | | | | | |
| 1975 | 52,248 | 881 | 53,129 | 2,431 | 2,426 | | 4,857 | | | | | | | | | | | | |
| 1976 | 43,604 | 2,149 | 45,753 | 2,297 | 3,147 | | 5,444 | 1,013 | | | | 2,427 | | 726 | 167 | | | | |
| 1977 | 15,784 | 392 | 16,176 | 5,244 | 5,604 | | 10,848 | 1,362 | | | | 1,512 | | | | | | | |
| 1978 | 32,235 | | 32,235 | 1,882 | 1,770 | | 3,652 | 60 | | | | 1,120 | | | | | | | |
| 1979 | 47,758 | | 47,758 | 8,729 | 4,430 | | 13,159 | | | | | | | | | | | | |
| 1980 | 21,961 | | 21,961 | 9,503 | 4,940 | | 14,443 | | | | | | | | | | | | |
| 1981 | 26,261 | 2,951 | 29,212 | 10,272 | 6,933 | | 17,205 | 3,133 | | | | 3,356 | | | | | | | |
| 1982 | 17,731 | 235 | 17,966 | 19,525 | 7,270 | | 26,795 | 785 | | | | 700 | 30 | | | | | | |
| 1983 | 26,226 | | 26,226 | 8,756 | 5,227 | | 13,983 | | | | | 1,000 | 100 | | | | | | |
| 1984 | 36,898 | 67 | 36,965 | 21,581 | 8,312 | | 29,893 | 4,000 | | | | 500 | 90 | 250 | | | | | |
| 1985 | 52,120 | | 52,120 | 16,320 | 12,792 | 10,696 | 39,808 | 700 | | | | | | | | | | | |
| 1986 | 68,593 | 228 | 68,821 | 12,481 | 11,508 | 7,263 | 31,252 | | | | | | | | | | | | |
| 1987 | 76,562 | | 76,562 | 16,256 | 5,868 | 2,125 | 24,249 | | | | | | | | | | | | |
| 1988 | 63,998 | | 63,998 | 13,615 | 51,923 | 1,937 | 67,475 | 4,453 | | | | | | | | | | | |
| 1989 | 48,968 | | 48,968 | 11,986 | 18,829 | 233 | 31,048 | 2,153 | | | | | | | | | | | |
| 1990 | 32,109 | | 32,109 | 14,635 | 6,453 | | 21,088 | 1,011 | | | | | | | | | | | |
| 1991 | 20,523 | | 20,523 | 10,683 | 6,558 | | 17,241 | 2,026 | | | | 676 | | | | | | | |
| 1992 | 23,914 | | 23,914 | 7,275 | 5,433 | | 12,708 | 600 | | | | 1,585 | | | | | | | |
| 1993 | 33,471 | | 33,471 | 7,587 | 11,029 | | 18,616 | 1,246 | | | | | | | | | | | |
| 1994 | 44,729 | | 44,729 | 18,991 | 24,274 | | 43,265 | 2,546 | | | | | | | | | | | |
| 1995 | 53,385 | | 53,385 | 26,677 | 56,515 | | 83,192 | 9,298 | | | | | | | | | | | |
| 1996 | 71,725 | | 71,725 | 21,178 | 52,409 | | 73,587 | 5,922 | | | | | | | | | | | |
| 1997 | 98,765 | | 98,765 | 50,670 | 50,744 | | 101,414 | 8,569 | | | | | | | | | | | |
| 1998 | 5,718 | | 5,718 | 44,351 | 53,957 | | 98,308 | 4,259 | | | | | | | | | | | |
| 1999 | 133,365 | | 133,365 | 26,970 | 92,929 | | 119,899 | 8,003 | | | | | | | | | | | |
| 2000 | 87,793 | | 87,793 | 21,659 | 53,447 | | 75,106 | 6,687 | | | | | | | | | | | |
| 2001 | 57,792 | | 57,792 | 25,082 | 100,604 | | 125,686 | 10,865 | | | | | | | | | | | |
| 2002 | 45,523 | | 45,523 | 66,147 | 397,149 | | 463,296 | 16,071 | | | | | | | | | | | |
| 2003 | 66,476 | | 66,476 | 88,281 | 64,764 | | 153,045 | 9,475 | | | | | | | | | | | |
| 2004 | 34,050 | | 34,050 | 68,232 | 23,861 | | 92,093 | 6,365 | | | | | | | | | | | |
| [2005] | 44,950 | | 44,950 | 142,283 | 20,520 | | 162,803 | 14,824 | | | | | | | | | | | |
| [2006] | 46,568 | | 46,568 | 58,017 | 19,493 | | 77,510 | 8,422 | | | | | | 4,130 | | | | | |

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY.
BLANK ENTRY INDICATES THAT TRIBUTARY WAS NOT SURVEYED, OR THAT NO ESTIMATE WAS MADE.

1/ Salmon from the mainstem population that were trapped at Keswick Dam and transported to Coleman National Fish Hatchery (CNFH).
* fish trapped at both Keswick and Anderson-Cottonwood Irriration District dams.

2/ Salmon that entered CNFH and were released back into Battle Creek upstream of the hatchery.

3/ The data source did not provide a breakdown corresponding to this compilation.

The spawner population was reported only for the entire mainstem from Keswick Dam to Princeton Ferry. Those numbers are Page 2 in the Summary , page 5 of Fall Run.

# FALL-RUN CHINOOK SALMON SPAWNER POPULATIONS

SACRAMENTO RIVER SYSTEM : Red Bluff Diversion Dam to Princeton ferry

| YEAR | Sacramento River Mainstem In-river | Sacramento River Mainstem Transfer to TCFF 1/ | Sacramento River Mainstem TOTAL | TCFF | Salt Cr. | Antelope Cr. | Craig Cr. | Dye Cr. | Mill Cr. | Toomes Cr. | Thomes Cr. | Deer Cr. | Coyote Cr. | Stoney Cr. | Singer Cr. | Big Chico Cr. | Other 2/ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1952 | a/ | | | | | | | | 16,000 | | | 12,000 | | | | | 3,000 |
| 1953 | a/ | | | | | 4,000 | | | 10,000 | | | 4,000 | | | | | 700 |
| 1954 | a/ | | | | | 1,000 | | | 7,000 | | | 3,000 | | | | | 2,000 |
| 1955 | a/ | | | | | 900 | | | 3,000 | | | | | | | | 600 |
| 1956 | 5,800 | | 5,800 | | | 327 | | | 896 | 5 | | 120 | | | | | 1,500 |
| 1957 | 12,200 | | 12,200 | | | 838 | | 25 | 5,316 | | 25 | 2,195 | | | | 50 | 800 |
| 1958 | 20,600 | | 20,600 | | | 400 | | | 4,340 | | | 1,300 | | | | | 2,200 |
| 1959 | 9,900 | | 9,900 | | | | | | 837 | | | 10 | | | | | 1,500 |
| 1960 | 14,000 | | 14,000 | | | 250 | | | 940 | | | 800 | | | | | |
| 1961 | 9,400 | | 9,400 | | | | | | 1,689 | | | | | | | | |
| 1962 | 8,500 | | 8,500 | | | 800 | | | 4,384 | | | 2,000 | | | | | |
| 1963 | 6,800 | | 6,800 | | | 300 | | | 1,286 | | | 1,249 | | | | | |
| 1964 | 5,500 | | 5,500 | | | 50 | | | 450 | | | 100 | | | | | |
| 1965 | 1,500 | | 1,500 | | | 60 | | | 150 | | | 200 | | | | | |
| 1966 | 3,100 | | 3,100 | | | 200 | | | 500 | | | 100 | | | | | |
| 1967 | 9,200 | | 9,200 | | | 60 | | | 500 | | | 60 | | | | | |
| 1968 | 11,800 | | 11,800 | | | 80 | | | 750 | | | 270 | | | | | |
| 1969 | 17,600 | | 17,600 | | | 180 | | 20 | 1,700 | 40 | | 750 | | | | | |
| 1970 | 5,860 | | 5,860 | | | 400 | | | 690 | | | 500 | | | | | |
| 1971 | 22,920 | 4,741 | 27,661 | 295 | | 205 | | 100 | 980 | | | 248 | | | | | |
| 1972 | 15,350 | 1,671 | 17,021 | 110 | 30 | 275 | | 50 | 631 | 25 | | 304 | | | 15 | | |
| 1973 | 16,599 | 2,491 | 19,090 | 886 | 43 | 200 | 90 | 153 | 420 | 40 | | 676 | | | 90 | | |
| 1974 | 27,127 | 2,234 | 29,361 | 843 | | 440 | 140 | | 944 | | 60 | 640 | 100 | | | | |
| 1975 | 34,200 | 1,973 | 36,173 | 1,994 | | 90 | 270 | | 1,208 | | 170 | 328 | 160 | | | | |
| 1976 | 36,100 | 1,882 | 37,982 | 1,430 | | 60 | | | 245 | 20 | | 315 | 160 | | | | |
| 1977 | 44,074 | 3,146 | 47,220 | 1,669 | | 660 | | | 318 | 120 | | 220 | 200 | | | | |
| 1978 | 45,921 | 2,085 | 48,006 | 2,052 | | | | | 300 | | | 90 | | | | | |
| 1979 | 64,932 | 53 | 64,985 | 2,456 | | | | | 810 | | | 780 | | | | | |
| 1980 | 28,413 | 175 | 28,588 | 1,865 | | | | | 320 | | 151 | 210 | | | | | |
| 1981 | 40,340 | | 40,340 | 2,384 | | 407 | 100 | | 1,020 | | 167 | 820 | | 393 | | | |
| 1982 | 22,578 | | 22,578 | 1,225 | 20 | 162 | 90 | 25 | 1,290 | 15 | | 480 | | | | | |
| 1983 | 30,751 | | 30,751 | 1,267 | 15 | 60 | 60 | 20 | 200 | 15 | | 370 | | | | 500 | |
| 1984 | 17,960 | | 17,960 | 1,206 | 30 | 260 | 60 | 50 | 5,800 | 50 | | 680 | | | 20 | 200 | |
| 1985 | 42,028 | | 42,028 | 4,752 | | | | | 3,840 | | | 900 | | | | 25 | |
| 1986 | 38,544 | | 38,544 | | | | | | 574 | | | 256 | | | | | |
| 1987 | 31,120 | | 31,120 | | | | | | 282 | | | 64 | | | | | |
| 1988 | 18,262 | | 18,262 | | | | | | 1,487 | | | | | | | | |
| 1989 | 10,101 | | 10,101 | | | | | | 1,565 | | | 358 | | | | | |
| 1990 | 16,175 | | 16,175 | | | | | | | | | | | | | | |
| 1991 | 10,108 | | 10,108 | | | | | | | | | | | | | | |
| 1992 | 8,315 | | 8,315 | | | 0 | | | 999 | | | | | | | | |
| 1993 | 12,760 | | 12,760 | | | | | | 1,975 | | | 72 | | | | | |
| 1994 | 13,817 | | 13,817 | | | | | | 1,081 | | | 307 | | | | | |
| 1995 | 10,549 | | 10,549 | | | | | | | | | | | | | | |
| 1996 | 12,361 | | 12,361 | | | | | | | | | | | | | | |
| 1997 | 20,531 | | 20,531 | | | | | | 478 | | | 1,203 | | | | | |
| 1998 | 600 | | 600 | | | | | | 546 | | | 270 | | | | | |
| 1999 | 27,827 | | 27,827 | | | | | | | | | | | | | | |
| 2000 | 8,895 | | 8,895 | | | | | | | | | | | | | | |
| 2001 | 17,360 | | 17,360 | | | | | | | | | | | | | | |
| 2002 | 20,167 | | 20,167 | | | | | | 2,611 | | | | | | | | |
| 2003 | 22,753 | | 22,753 | | | | | | 2,426 | | | | | | | | |
| 2004 | 9,554 | | 9,554 | | | | | | 1,192 | | | 300 | | | | | |
| [2005] | 12,063 | | 12,063 | | | | | | 2,426 | | | 963 | | | | | |
| [2006] | 8,900 | | 8,900 | | | | | | 1,403 | | | 1,905 | | | | | |

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY.
BLANK ENTRY INDICATES THAT TRIBUTARY WAS NOT SURVEYED, OR THAT NO ESTIMATE WAS MADE.

1/ Salmon from the mainstem population that were trapped at Red Bluff Diversion Dam and transported to Tehama-Colusa Fish Facility (TCFF).

2/ Miscellaneous small tributaries; the data source did not provide a breakdown corresponding to this compilation. NOTE: The number of fish listed may include those for tributaries from Keswick Dam to RBDD.

a/ The spawner population was reported only for the entire mainstem from Keswick Dam to Princet Bag ose numbers are only included in the Summary , page 5 of Fall Run.

# FALL-RUN CHINOOK SALMON SPAWNER POPULATIONS

## SACRAMENTO RIVER SYSTEM : Princeton Ferry to Sacramento

| YEAR | Butte Cr. | Feather River: Feather R. Hatchery | Feather River: In-river | Feather River: TOTAL | Yuba River | Bear River | Dry Cr. | American River: Nimbus Hatchery | American River: In-river | American River: TOTAL | Natomas Drain. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1952 | | | | | | | | | 25,000 | **25,000** | |
| 1953 | | | 28,000 | 28,000 | 6,000 | | | | 28,000 | **28,000** | |
| 1954 | | | 68,000 | 68,000 | 5,000 | | | | 29,000 | **29,000** | |
| 1955 | | | 86,000 | 86,000 | 2,000 | | | 8,000 | 9,000 | **17,000** | |
| 1956 | | | 18,200 | 18,200 | 5,000 | | | 1,537 | 4,900 | **6,437** | |
| 1957 | | | 10,750 | 10,750 | 1,205 | | | 875 | 6,832 | **7,707** | |
| 1958 | | | 34,650 | 34,650 | 7,900 | | | 9,571 | 17,300 | **26,871** | |
| 1959 | | | 80,150 | 80,150 | 10,000 | | | 13,243 | 17,900 | **31,143** | |
| 1960 | | | 83,300 | 83,300 | 20,400 | | | 29,166 | 25,200 | **54,366** | |
| 1961 | | | 43,700 | 43,700 | 9,200 | | | 14,309 | 11,200 | **25,509** | |
| 1962 | | | 19,050 | 19,050 | 34,300 | | | 12,653 | 14,400 | **27,053** | |
| 1963 | | | 33,900 | 33,900 | 37,000 | | | 3,211 | 37,810 | **41,021** | 460 |
| 1964 | | 5,952 a/ | 32,400 | 38,352 | 34,900 | | | 20,671 | 38,500 | **59,171** | 1,000 |
| 1965 | 0 | 3,635 a/ | 19,600 | 23,235 | 10,200 | | | 13,569 | 25,000 | **38,569** | 200 |
| 1966 | 0 | 1,850 a/ | 19,000 | 20,850 | 7,800 | | | 8,096 | 18,600 | **26,696** | |
| 1967 | | 1,856 | 10,100 | 11,956 | 23,500 | | | 5,147 | 18,000 | **23,147** | |
| 1968 | | 5,944 | 12,200 | 18,144 | 7,000 | | | 5,233 | 26,100 | **31,333** | 100 |
| 1969 | | 4,378 | 56,200 | 60,578 | 5,230 | | | 3,065 | 44,200 | **47,265** | |
| 1970 | | 3,355 | 58,170 | 61,525 | 13,830 | | | 8,629 | 28,680 | **37,309** | |
| 1971 | 615 | 3,541 | 43,500 | 47,041 | 5,650 | | | 10,110 | 41,680 | **51,790** | |
| 1972 | 450 | 3,635 | 43,200 | 46,835 | 9,258 | | | 7,042 | 17,459 | **24,501** | |
| 1973 | | 8,477 | 65,100 | 73,577 | 24,119 | | | 12,535 | 82,242 | **94,777** | |
| 1974 | 200 | 5,248 | 60,518 | 65,766 | 17,809 | | | 8,200 | 53,596 | **61,796** | |
| 1975 | 1,000 | 5,265 | 37,735 | 43,000 | 5,641 | | | 7,412 | 32,132 | **39,544** | |
| 1976 | 640 | 5,198 | 56,802 | 62,000 | 3,779 | | | 5,215 | 23,159 | **28,374** | |
| 1977 | | 8,784 | 37,668 | 46,452 | 8,722 | | | 6,868 | 41,605 | **48,473** | |
| 1978 | 20 | 4,759 | 33,000 | 37,759 | 7,416 | | | 8,162 | 12,929 | **21,091** | |
| 1979 | | 4,090 | 28,415 | 32,505 | 12,430 | | | 10,351 | 37,315 | **47,666** | |
| 1980 | | 3,690 | 31,605 | 35,295 | 12,406 | | | 15,543 | 34,259 | **49,802** | |
| 1981 | | 8,282 | 44,738 | 53,020 | 14,025 | | | 20,593 | 43,462 | **64,055** | |
| 1982 | | 7,563 | 47,956 | 55,519 | 39,367 | | | 10,898 | 33,000 | **43,898** | |
| 1983 | 1,000 | 7,699 | 22,823 | 30,522 | 13,756 | | 500 | 8,900 | 26,400 | **35,300** | |
| 1984 | | 9,288 | 41,769 | 51,057 | 9,665 | 300 | | 12,249 | 27,447 | **39,696** | |
| 1985 | 100 | 5,811 | 50,191 | 56,002 | 13,042 | | 25 | 9,093 | 56,120 | **65,213** | |
| 1986 | | 8,628 | 46,843 | 55,471 | 19,328 | | | 5,695 | 49,372 | **55,067** | |
| 1987 | | 10,108 | 67,738 | 77,846 | 18,518 | | | 6,258 | 39,885 | **46,143** | |
| 1988 | | 6,480 | 42,556 | 49,036 | 9,000 | | | 8,625 | 24,889 | **33,514** | |
| 1989 | | 7,578 | 40,541 | 48,119 | 7,622 | | | 9,741 | 19,183 | **28,924** | |
| 1990 | | 6,126 | | 6,126 | | | | 4,850 | 5,389 | **10,239** | |
| 1991 | | 10,717 | 31,345 | 42,062 | 14,008 | | | 7,128 | 18,083 | **25,211** | |
| 1992 | | 16,440 | 24,105 | 40,545 | 6,362 | | | 6,456 | 4,811 | **11,267** | |
| 1993 | | 11,991 | 30,923 | 42,914 | 6,703 | | | 10,656 | 28,754 | **39,410** | |
| 1994 | | 15,202 | 38,382 | 53,584 | 10,890 | | | 8,567 | 31,520 | **40,087** | |
| 1995 | 445 | 12,149 | 59,912 | 72,061 | 14,237 | | | 6,498 | 80,330 | **86,828** | |
| 1996 | 500 | 8,107 | 57,170 | 65,277 | 27,900 | | | 7,651 | 74,745 | **82,396** | |
| 1997 | 800 | 15,128 | 50,547 | 65,675 | 25,948 | | | 5,650 | 52,195 | **57,845** | |
| 1998 | 500 | 18,889 | -- | 18,889 | 31,090 | | | 11,788 | 54,792 | **66,580** | |
| 1999 | | 12,927 | -- | 12,927 | 24,230 | | | 9,760 | 55,339 | **65,099** | |
| 2000 | | 18,146 | 114,717 | 132,863 | 14,995 | | | 11,160 | 99,059 | **110,219** | |
| 2001 | 4,430 | 24,870 | 178,645 | 203,515 | 23,392 | | | 11,750 | 135,384 | **147,134** | |
| 2002 | 4,550 | 20,507 | 105,163 | 125,670 | 24,051 | | | 9,817 | 124,252 | **134,069** | |
| 2003 | 3,310 | 14,976 | 89,946 | 104,922 | 28,316 | | | 14,887 | 163,742 | **178,629** | |
| 2004 | 2,516 | 21,297 | 54,171 | 75,468 | 15,269 | | | 26,400 | 99,230 | **125,630** | |
| [2005] | 4,255 | 22,201 | 49,160 | 71,361 | 15,048 | | | 22,349 | 62,679 | **85,028** | |
| [2006] | 1,920 | 11,581 | 81,700 | 93,281 | 8,127 | | | 8,728 | 21,000 | **29,728** | |

## SAN JOAQUIN RIVER SYSTEM : Tributaries

| YEAR | Cosumnes River | Mokelumne River: MRFI 1/ | Mokelumne River: In-river | Mokelumne River: TOTAL | Stanislaus River | Tuolumne River | Merced River: MRFF 2/ | Merced River: In-river | Merced River: TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| 1952 | | | 2,000 | 2,000 | 10,000 | 10,000 | | | |
| 1953 | 2,000 | | 2,000 | 2,000 | 35,000 | 45,000 | | | |
| 1954 | 5,000 | | 4,000 | 4,000 | 22,000 | 40,000 | | 4,000 | **4,000** |
| 1955 | 2,000 | | 2,000 | 2,000 | 7,000 | 20,000 | | | |
| 1956 | 1,200 | | 474 | 474 | 5,000 | 5,500 | | | |
| 1957 | 142 | | 2,400 | 2,400 | 4,090 | 8,170 | | 380 | **380** |
| 1958 | 600 | | 7,579 | 7,579 | 5,700 | 32,500 | | 500 | **500** |
| 1959 | | | 2,106 | 2,106 | 4,300 | 45,900 | | 400 | **400** |
| 1960 | 1,400 | | 2,205 | 2,205 | 8,300 | 45,000 | | 350 | **350** |
| 1961 | | | 137 | 137 | 1,900 | 500 | | 50 | **50** |
| 1962 | 900 | | 230 | 230 | 315 | 250 | | 60 | **60** |
| 1963 | 1,500 | | 481 | 481 | 200 | 100 | | 20 | **20** |
| 1964 | 2,200 | 362 | 1,848 | 2,210 | 3,700 | 2,100 | | 35 | **35** |
| 1965 | 800 | 173 | 1,127 | 1,300 | 2,231 | 3,200 | | 90 | **90** |
| 1966 | 600 | 480 | 209 | 689 | 2,872 | 5,100 | | 45 | **45** |
| 1967 | 500 | 250 | 2,750 | 3,000 | 11,885 | 6,800 | | 600 | **600** |
| 1968 | 1,500 | 954 | 753 | 1,707 | 6,385 | 8,600 | | 550 | **550** |
| 1969 | 4,400 | 615 | 2,070 | 2,685 | 12,327 | 32,200 | | 600 | **600** |
| 1970 | 600 | 548 | 4,452 | 5,000 | 9,297 | 18,400 | 100 | 4,700 | **4,800** |
| 1971 | 500 | 925 | 4,275 | 5,200 | 13,621 | 21,885 | 200 | 3,451 | **3,651** |
| 1972 | 1,600 | 352 | 750 | 1,102 | 4,298 | 5,100 | 120 | 2,528 | **2,648** |
| 1973 | 900 | 407 | 2,193 | 2,600 | 1,234 | 1,989 | 375 | 797 | **1,172** |
| 1974 | 285 | 222 | 1,200 | 1,422 | 750 | 1,150 | 1,000 | 1,000 | **2,000** |
| 1975 | 725 | 399 | 1,501 | 1,900 | 1,200 | 1,600 | 700 | 1,700 | **2,400** |
| 1976 | | 18 | 455 | 473 | 600 | 1,700 | 700 | 1,200 | **1,900** |
| 1977 | | 0 | 250 | 250 | 0 | 450 | 661 a. | 350 | **1,011** |
| 1978 | 100 | 486 | 600 | 1,086 | 50 | 1,300 | 100 | 525 | **625** |
| 1979 | 150 | 507 | 1,000 | 1,507 | 110 | 1,183 | 227 | 1,920 | **2,147** |
| 1980 | 200 | 639 | 2,592 | 3,231 | 100 | 559 | 157 | 2,849 | **3,006** |
| 1981 | | | 4,954 | 4,954 | 1,000 | 14,253 | 924 | 9,491 | **10,415** |
| 1982 | | 2,677 | 6,695 | 9,372 | | 7,126 | 189 | 3,074 | **3,263** |
| 1983 | 200 | 4,568 | 11,293 | 15,861 | 500 | 14,836 | 1,795 | 16,453 | **18,248** |
| 1984 | 1,000 | | 8,298 | 8,298 | 11,439 | 13,689 | 2,109 | 27,640 | **29,749** |
| 1985 | 220 | 223 | 7,459 | 7,682 | 13,473 | 40,322 | 1,211 | 14,841 | **16,052** |
| 1986 | | 1,913 | 5,254 | 7,167 | 6,497 | 7,404 | 650 | 6,789 | **7,439** |
| 1987 | 0 | 630 | 1,000 | 1,630 | 6,292 | 14,751 | 958 | 3,168 | **4,126** |
| 1988 | 100 | 128 | 400 | 528 | 10,212 | 5,779 | 457 | 4,135 | **4,592** |
| 1989 | | 81 | 199 | 280 | 1,510 | 1,275 | 82 | 345 | **427** |
| 1990 | | 68 | 429 | 497 | 480 | 96 | 46 | 36 | **82** |
| 1991 | | 42 | 368 | 410 | 394 | 77 | 41 | 78 | **119** |
| 1992 | | 710 | 935 | 1,645 | 255 | 132 | 368 | 618 | **986** |
| 1993 | | 2,164 | 993 | 3,157 | 677 | 471 | 409 | 1,269 | **1,678** |
| 1994 | | 1,919 | 1,238 | 3,157 | 1,031 | 506 | 943 | 2,646 | **3,589** |
| 1995 | | 3,323 | 2,194 | 5,517 | 619 | 827 | 602 | 2,320 | **2,922** |
| 1996 | | 3,883 | 4,038 | 7,921 | 168 | 4,362 | 1,141 | 3,291 | **4,432** |
| 1997 | | 6,494 | 3,681 | 10,175 | 5,588 | 7,146 | 946 | 2,714 | **3,660** |
| 1998 | 300 | 3,091 | 4,122 | 7,213 | 3,087 | 8,910 | 799 | 3,292 | **4,091** |
| 1999 | | 3,150 | 2,183 | 5,333 | 4,349 | 8,232 | 1,637 | 3,129 | **4,766** |
| 2000 | | 5,450 | 1,973 | 7,423 | 8,498 | 17,873 | 1,946 | 11,130 | **13,076** |
| 2001 | | 5,728 | 2,307 | 8,035 | 7,033 | 8,782 | 1,663 | 9,181 | **10,844** |
| 2002 | | 7,913 | 2,840 | 10,753 | 7,787 | 7,173 | 1,840 | 8,866 | **10,706** |
| 2003 | | 8,117 | 2,122 | 10,239 | 5,902 | 2,163 | 549 | 2,530 | **3,079** |
| 2004 | | 10,356 | 1,588 | 11,944 | 4,015 | 1,984 | 3,270 | 1,050 | **4,320** |
| [2005] | | 5,738 | 10,406 | 16,144 | 1,429 | 500 | 421 | 2,500 | **2,921** |
| [2006] | | 4,116 | 1,723 | 5,839 | 3,022 | 500 | 150 | 2,000 | **2,150** |

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY.
BLANK ENTRY INDICATES THAT TRIBUTARY WAS NOT SURVEYED, OR THAT NO ESTIMATE WAS MADE.

a/ Fish were transferred to upstream of Oroville dam.

1/ Mokelumne River Hatchery.

2/ Merced River Hatchery.

a/ Consists of fish that were trapped in the San Joaquin River mainstem. Only 389 of these were actually

transported to the hatchery spawning channel.

# FALL-RUN CHINOOK SALMON SPAWNER POPULATIONS

## SACRAMENTO RIVER SYSTEM : SUMMARY

| YEAR | Keswick Dam to Red Bluff Diversion Dam | | | | Red Bluff Diversion Dam to Princeton Ferry | | | | Princeton Ferry to Sacramento | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | In-river | | | | In-river | | | | In-river | |
| | CNFF 1/ | Mainstem | Tributaries | TOTAL | TCFF 2/ | Mainstem | Tributaries | TOTAL | Hatcheries 3/ | Tributaries | TOTAL |
| 1952 | 11,000 | 7,000 a/ | 4,000 | **22,000** | | b/ | 31,000 c/ | **31,000** | | 25,000 | **25,000** |
| 1953 | 12,000 | 8,000 a/ | 12,300 | **32,300** | | b/ | 18,700 c/ | **18,700** | | 62,000 | **62,000** |
| 1954 | 8,000 | 6,000 a/ | 13,000 | **27,000** | | b/ | 13,000 c/ | **13,000** | | 102,000 | **102,000** |
| 1955 | 10,000 | 6,000 a/ | 18,800 | **34,800** | | b/ | 4,500 c/ | **4,500** | 8,000 | 97,000 | **105,000** |
| 1956 | 7,458 | 87,357 | 21,500 | **116,315** | | 5,800 | 2,848 c/ | **8,648** | 1,537 | 28,100 | **29,637** |
| 1957 | 3,045 | 54,989 | 3,853 | **61,887** | | 12,200 | 9,249 c/ | **21,449** | 875 | 18,787 | **19,662** |
| 1958 | 14,643 | 107,153 | 20,530 | **142,326** | | 20,600 | 8,240 c/ | **28,840** | 9,571 | 59,850 | **69,421** |
| 1959 | 10,833 | 256,700 | 25,120 | **292,653** | | 9,900 | 2,347 c/ | **12,247** | 13,243 | 108,050 | **121,293** |
| 1960 | 9,605 | 218,940 | 16,160 | **244,705** | | 14,000 | 1,990 | **15,990** | 29,166 | 128,900 | **158,066** |
| 1961 | 8,156 | 140,181 | 13,200 | **161,537** | | 9,400 | 1,689 | **11,089** | 14,309 | 64,100 | **78,409** |
| 1962 | 4,857 | 127,837 | 21,100 | **153,794** | | 8,500 | 7,184 | **15,684** | 12,653 | 67,750 | **80,403** |
| 1963 | 5,114 | 138,881 | 25,900 | **169,895** | | 6,800 | 2,835 | **9,635** | 3,211 | 109,170 | **112,381** |
| 1964 | 3,875 | 142,584 | 19,000 | **165,459** | | 5,500 | 600 | **6,100** | 26,623 | 106,800 | **133,423** |
| 1965 | 3,194 | 101,876 | 10,785 | **115,855** | | 1,500 | 410 | **1,910** | 17,204 | 55,000 | **72,204** |
| 1966 | 900 | 111,881 | 14,500 | **127,281** | | 3,100 | 800 | **3,900** | 9,946 | 45,400 | **55,346** |
| 1967 | 3,050 | 82,490 | 3,680 | **89,220** | | 9,200 | 620 | **9,820** | 7,003 | 51,600 | **58,603** |
| 1968 | 3,526 | 98,429 | 20,140 | **122,095** | | 11,800 | 1,100 | **12,900** | 11,177 | 45,400 | **56,577** |
| 1969 | 2,626 | 115,652 | 16,537 | **134,815** | | 17,600 | 2,690 | **20,290** | 7,443 | 105,630 | **113,073** |
| 1970 | 3,512 | 65,142 | 8,628 | **77,282** | | 5,860 | 1,590 c/ | **7,450** | 11,984 | 100,680 | **112,664** |
| 1971 | 2,004 | 53,888 | 3,285 | **59,177** | 295 | 27,661 | 1,828 | **29,784** | 13,651 | 91,445 | **105,096** |
| 1972 | 2,822 | 33,958 | 2,030 | **38,810** | 110 | 17,021 | 1,440 | **18,571** | 10,677 | 70,367 | **81,044** |
| 1973 | 3,835 | 41,129 | 4,300 | **49,264** | 886 | 19,090 | 2,598 | **22,574** | 21,012 | 171,461 | **192,473** |
| 1974 | 1,607 | 47,019 | 2,294 | **50,920** | 843 | 29,361 | 3,167 | **33,371** | 13,448 | 132,123 | **145,571** |
| 1975 | 2,431 | 53,129 | 2,426 | **57,986** | 1,994 | 36,173 | 4,220 | **42,387** | 12,677 | 76,508 | **89,185** |
| 1976 | 2,297 | 45,753 | 7,480 | **55,530** | 1,430 | 37,982 | 2,230 | **41,642** | 10,413 | 84,380 | **94,793** |
| 1977 | 5,244 | 16,176 | 8,478 | **29,898** | 1,669 | 47,220 | 3,187 | **52,076** | 15,652 | 87,995 | **103,647** |
| 1978 | 1,882 | 32,235 | 2,950 | **37,067** | 2,052 | 48,006 | 2,442 | **52,500** | 12,921 | 53,365 | **66,286** |
| 1979 | 8,729 | 47,758 | 4,430 | **60,917** | 2,456 | 64,985 | 4,046 | **71,487** | 14,441 | 78,160 | **92,601** |
| 1980 | 9,503 | 21,961 | 4,940 | **36,404** | 1,865 | 28,588 | 2,546 | **32,999** | 19,233 | 78,270 | **97,503** |
| 1981 | 10,272 | 29,212 | 13,422 | **52,906** | 2,384 | 40,340 | 5,291 | **48,015** | 28,875 | 102,225 | **131,100** |
| 1982 | 19,525 | 17,966 | 8,785 | **46,276** | 1,225 | 22,578 | 3,307 | **27,110** | 18,461 | 120,323 | **138,784** |
| 1983 | 8,756 | 26,226 | 6,327 | **41,309** | 1,267 | 30,751 | 2,507 | **34,525** | 16,599 | 64,479 | **81,078** |
| 1984 | 21,581 | 36,965 | 13,152 | **71,698** | 1,206 | 17,960 | 8,356 | **27,522** | 21,537 | 79,181 | **100,718** |
| 1985 | 16,320 | 52,120 | 24,188 | **92,628** | 4,752 | 42,028 | 9,517 | **56,297** | 14,904 | 119,478 | **134,382** |
| 1986 | 12,481 | 68,821 | 18,771 | **100,073** | | 38,544 | 830 | **39,374** | 14,323 | 115,543 | **129,866** |
| 1987 | 16,256 | 76,562 | 7,993 | **100,811** | | 31,120 | 346 | **31,466** | 16,366 | 126,141 | **142,507** |
| 1988 | 13,615 | 63,998 | 58,313 | **135,926** | | 18,262 | 1,487 | **19,749** | 15,105 | 76,445 | **91,550** |
| 1989 | 11,986 | 48,968 | 21,215 | **82,169** | | 10,101 | 1,923 | **12,024** | 17,319 | 67,346 | **84,665** |
| 1990 | 14,635 | 32,109 | 7,464 | **54,208** | | 16,175 | | **16,175** | 10,976 | 5,389 | **16,365** |
| 1991 | 10,683 | 20,523 | 9,260 | **40,466** | | 10,108 | | **10,108** | 17,845 | 63,436 | **81,281** |
| 1992 | 7,275 | 23,914 | 7,618 | **38,807** | | 8,315 | 999 | **9,314** | 22,896 | 35,278 | **58,174** |
| 1993 | 7,587 | 33,471 | 12,275 | **53,333** | | 12,760 | 2,047 | **14,807** | 22,647 | 66,380 | **89,027** |
| 1994 | 18,991 | 44,729 | 26,820 | **90,540** | | 13,817 | 1,388 | **15,205** | 23,769 | 80,792 | **104,561** |
| 1995 | 26,677 | 53,385 | 65,813 | **145,875** | | 10,549 | | **10,549** | 18,647 | 154,924 | **173,571** |
| 1996 | 21,178 | 71,725 | 58,331 | **151,234** | | 12,361 | | **12,361** | 15,758 | 160,315 | **176,073** |
| 1997 | 50,670 | 98,765 | 59,313 | **208,748** | | 20,531 | 1,681 | **22,212** | 20,778 | 129,490 | **150,268** |
| 1998 | 44,351 | 5,718 | 58,216 | **108,285** | | 600 | 816 | **1,416** | 30,677 | 86,382 | **117,059** |
| 1999 | 26,970 | 133,365 | 100,932 | **261,267** | | 27,827 | | **27,827** | 22,687 | 79,569 | **102,256** |
| 2000 | 21,659 | 87,793 | 60,134 | **169,586** | | 8,895 | | **8,895** | 29,306 | 228,771 | **258,077** |
| 2001 | 25,082 | 57,792 | 111,469 | **194,343** | | 17,360 | | **17,360** | 36,620 | 341,851 | **378,471** |
| 2002 | 66,147 | 45,523 | 413,220 | **524,890** | | 20,167 | 2,611 | **22,778** | 30,324 | 258,016 | **288,340** |
| 2003 | 88,281 | 66,476 | 74,239 | **228,996** | | 22,753 | 2,426 | **25,179** | 29,863 | 285,314 | **315,177** |
| 2004 | 68,232 | 34,050 | 30,226 | **132,508** | | 9,554 | 1,492 | **11,046** | 47,697 | 171,186 | **218,883** |
| [2005] | 142,283 | 44,950 | 35,344 | **222,577** | | 12,063 | 3,389 | **15,452** | 44,550 | 131,142 | **175,692** |
| [2006] | 58,017 | 46,568 | 32,045 | **136,630** | | 8,900 | 3,308 | **12,208** | 20,309 | 112,747 | **133,056** |

1/ Coleman National Fish Hatchery.

2/ Tehama-Colusa Fish Facility.

3/ Feather River and Nimbus Hatcheries.

a/ Salmon from the mainstem population that were trapped at Keswick Dam and transported to CNFF. For these years, the mainstem population was reported only for the entire reach from Keswick to Princeton.

b/ The spawner population was reported only for the entire mainstem from Keswick Dam to Princeton Ferry.

c/ The number may include fish for tributaries from Keswick Dam to RBDD. Pa 2

# FALL-RUN CHINOOK SALMON SPAWNER POPULATIONS

## CENTRAL VALLEY RIVER SYSTEMS : SUMMARY

| | Sacramento River System | | | | San Joaquin River System | | | Sacramento and San Joaquin River Systems | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | In-river | | | | In-river | | | | | |
| YEAR | Hatcheries 1/ | Mainstem | Tributaries | TOTAL | Hatcheries 2/ | Tributaries | TOTAL | Hatcheries | In-river | TOTAL | YEAR |
| 1952 | 11,000 | 267,000 | 60,000 | 338,000 | | 22,000 | 22,000 | 11,000 | 349,000 | 360,000 | 1952 |
| 1953 | 12,000 | 408,000 | 93,000 | 513,000 | | 84,000 | 84,000 | 12,000 | 585,000 | 597,000 | 1953 |
| 1954 | 8,000 | 276,000 | 128,000 | 412,000 | | 75,000 | 75,000 | 8,000 | 479,000 | 487,000 | 1954 |
| 1955 | 18,000 | 231,000 | 120,300 | 369,300 | | 31,000 | 31,000 | 18,000 | 382,300 | 400,300 | 1955 |
| 1956 | 8,995 | 93,157 | 52,448 | 154,600 | | 12,174 | 12,174 | 8,995 | 157,779 | 166,774 | 1956 |
| 1957 | 3,920 | 67,189 | 31,889 | 102,998 | | 15,182 | 15,182 | 3,920 | 114,260 | 118,180 | 1957 |
| 1958 | 24,214 | 127,753 | 88,620 | 240,587 | | 46,879 | 46,879 | 24,214 | 263,252 | 287,466 | 1958 |
| 1959 | 24,076 | 266,600 | 135,517 | 426,193 | | 52,706 | 52,706 | 24,076 | 454,823 | 478,899 | 1959 |
| 1960 | 38,771 | 232,940 | 147,050 | 418,761 | | 57,255 | 57,255 | 38,771 | 437,245 | 476,016 | 1960 |
| 1961 | 22,465 | 149,581 | 78,989 | 251,035 | | 2,587 | 2,587 | 22,465 | 231,157 | 253,622 | 1961 |
| 1962 | 17,510 | 136,337 | 96,034 | 249,881 | | 1,755 | 1,755 | 17,510 | 234,126 | 251,636 | 1962 |
| 1963 | 8,325 | 145,681 | 137,905 | 291,911 | | 2,301 | 2,301 | 8,325 | 285,887 | 294,212 | 1963 |
| 1964 | 30,498 | 148,084 | 126,400 | 304,982 | 362 | 9,883 | 10,245 | 30,860 | 284,367 | 315,227 | 1964 |
| 1965 | 20,398 | 103,376 | 66,195 | 189,969 | 173 | 7,448 | 7,621 | 20,571 | 177,019 | 197,590 | 1965 |
| 1966 | 10,846 | 114,981 | 60,700 | 186,527 | 480 | 8,826 | 9,306 | 11,326 | 184,507 | 195,833 | 1966 |
| 1967 | 10,053 | 91,690 | 55,900 | 157,643 | 250 | 22,535 | 22,785 | 10,303 | 170,125 | 180,428 | 1967 |
| 1968 | 14,703 | 110,229 | 66,640 | 191,572 | 954 | 17,788 | 18,742 | 15,657 | 194,657 | 210,314 | 1968 |
| 1969 | 10,069 | 133,252 | 124,857 | 268,178 | 615 | 51,597 | 52,212 | 10,684 | 309,706 | 320,390 | 1969 |
| 1970 | 15,496 | 71,002 | 110,898 | 197,396 | 648 | 37,449 | 38,097 | 16,144 | 219,349 | 235,493 | 1970 |
| 1971 | 15,950 | 81,549 | 96,558 | 194,057 | 1,125 | 43,732 | 44,857 | 17,075 | 221,839 | 238,914 | 1971 |
| 1972 | 13,609 | 50,979 | 73,837 | 138,425 | 472 | 14,276 | 14,748 | 14,081 | 139,092 | 153,173 | 1972 |
| 1973 | 25,733 | 60,219 | 178,359 | 264,311 | 782 | 7,113 | 7,895 | 26,515 | 245,691 | 272,206 | 1973 |
| 1974 | 15,898 | 76,380 | 137,584 | 229,862 | 1,222 | 4,385 | 5,607 | 17,120 | 218,349 | 235,469 | 1974 |
| 1975 | 17,102 | 89,302 | 83,154 | 189,558 | 1,099 | 6,726 | 7,825 | 18,201 | 179,182 | 197,383 | 1975 |
| 1976 | 14,140 | 83,735 | 94,090 | 191,965 | 718 | 3,955 | 4,673 | 14,858 | 181,780 | 196,638 | 1976 |
| 1977 | 22,565 | 63,396 | 99,660 | 185,621 | 661 | 1,050 | 1,711 | 23,226 | 164,106 | 187,332 | 1977 |
| 1978 | 16,855 | 80,241 | 58,757 | 155,853 | 586 | 2,575 | 3,161 | 17,441 | 141,573 | 159,014 | 1978 |
| 1979 | 25,626 | 112,743 | 86,636 | 225,005 | 734 | 4,363 | 5,097 | 26,360 | 203,742 | 230,102 | 1979 |
| 1980 | 30,601 | 50,549 | 85,756 | 166,906 | 796 | 6,300 | 7,096 | 31,397 | 142,605 | 174,002 | 1980 |
| 1981 | 41,531 | 69,552 | 120,938 | 232,021 | 924 | 29,698 | 30,622 | 42,455 | 220,188 | 262,643 | 1981 |
| 1982 | 39,211 | 40,544 | 132,415 | 212,170 | 2,866 | 16,895 | 19,761 | 42,077 | 189,854 | 231,931 | 1982 |
| 1983 | 26,622 | 56,977 | 73,313 | 156,912 | 6,363 | 43,282 | 49,645 | 32,985 | 173,572 | 206,557 | 1983 |
| 1984 | 44,324 | 54,925 | 100,689 | 199,938 | 2,109 | 62,066 | 64,175 | 46,433 | 217,680 | 264,113 | 1984 |
| 1985 | 35,976 | 94,148 | 153,183 | 283,307 | 1,434 | 76,315 | 77,749 | 37,410 | 323,646 | 361,056 | 1985 |
| 1986 | 26,804 | 107,365 | 135,144 | 269,313 | 2,563 | 25,944 | 28,507 | 29,367 | 268,453 | 297,820 | 1986 |
| 1987 | 32,622 | 107,682 | 134,480 | 274,784 | 1,588 | 25,211 | 26,799 | 34,210 | 267,373 | 301,583 | 1987 |
| 1988 | 28,720 | 82,260 | 136,245 | 247,225 | 585 | 20,626 | 21,211 | 29,305 | 239,131 | 268,436 | 1988 |
| 1989 | 29,305 | 59,069 | 90,484 | 178,858 | 163 | 3,329 | 3,492 | 29,468 | 152,882 | 182,350 | 1989 |
| 1990 | 25,611 | 48,284 | 12,853 | 86,748 | 114 | 1,041 | 1,155 | 25,725 | 62,178 | 87,903 | 1990 |
| 1991 | 28,528 | 30,631 | 72,696 | 131,855 | 83 | 917 | 1,000 | 28,611 | 104,244 | 132,855 | 1991 |
| 1992 | 30,171 | 32,229 | 43,895 | 106,295 | 1,078 | 1,940 | 3,018 | 31,249 | 78,064 | 109,313 | 1992 |
| 1993 | 30,234 | 46,231 | 80,702 | 157,167 | 2,573 | 3,410 | 5,983 | 32,807 | 130,343 | 163,150 | 1993 |
| 1994 | 42,760 | 58,546 | 109,000 | 210,306 | 2,862 | 5,421 | 8,283 | 45,622 | 172,967 | 218,589 | 1994 |
| 1995 | 45,324 | 63,934 | 220,737 | 329,995 | 3,925 | 5,960 | 9,885 | 49,249 | 290,631 | 339,880 | 1995 |
| 1996 | 36,936 | 84,086 | 218,646 | 339,668 | 5,024 | 11,859 | 16,883 | 41,960 | 314,591 | 356,551 | 1996 |
| 1997 | 71,448 | 119,296 | 190,484 | 381,228 | 7,440 | 19,129 | 26,569 | 78,888 | 328,909 | 407,797 | 1997 |
| 1998 | 75,028 | 6,318 | 145,414 | 226,760 | 3,890 | 19,711 | 23,601 | 78,918 | 171,443 | 250,361 | 1998 |
| 1999 | 49,657 | 161,192 | 180,501 | 391,350 | 4,787 | 17,893 | 22,680 | 54,444 | 359,586 | 414,030 | 1999 |
| 2000 | 50,965 | 96,688 | 288,905 | 436,558 | 7,396 | 39,474 | 46,870 | 58,361 | 425,067 | 483,428 | 2000 |
| 2001 | 61,702 | 75,152 | 453,320 | 590,174 | 7,391 | 27,303 | 34,694 | 69,093 | 555,775 | 624,868 | 2001 |
| 2002 | 96,471 | 65,690 | 673,847 | 836,008 | 9,753 | 26,666 | 36,419 | 106,224 | 766,203 | 872,427 | 2002 |
| 2003 | 118,144 | 89,229 | 361,979 | 569,352 | 8,666 | 12,717 | 21,383 | 126,810 | 463,925 | 590,735 | [2003 |
| 2004 | 115,929 | 43,604 | 202,904 | 362,437 | 13,626 | 8,637 | 22,263 | 129,555 | 255,145 | 384,700 | 2004 |
| [2005] | 186,833 | 57,013 | 169,875 | 413,721 | 6,159 | 14,835 | 20,994 | 192,992 | 241,723 | 434,715 | [2005] |
| [2006] | 78,326 | 55,468 | 148,100 | 281,894 | 4,266 | 7,245 | 11,511 | 82,592 | 210,813 | 293,405 | [2006] |

1/ Coleman National Fish Hatchery, Tehama-Clousa Fish Facility, and Feather River and Nimbus Hatcheries.

2/ Mokelumne River Fish Installation and Merced River Fish Facility.

# LATE-FALL-RUN CHINOOK SALMON POPULATIONS: Sacramento River System

| YEAR | Sacramento River Mainstem | | | | | | Battle Creek | | | Clear Creek | Cotton-wood Cr. | Salt Cr. | Craig Cr. | Feather River | | | TOTAL for RUN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Upstream of RBDD 1/ | | | Downstream of RBDD | | | | | | | | | | | | | |
| | In-river 2/ | CNFF 3/ | TOTAL | TCFF 4/ | In-river | TOTAL | In-river | CNFH | TOTAL | | | | | In-river | Hatchery | TOTAL | |
| 1971 | 16,741 | – | 16,741 | | | | | | | | | | | | | | 16,741 |
| 1972 | 31,559 | – | 31,559 | | | | | | | | | | | | | | 31,559 |
| 1973 | 21,781 | – | 21,781 | | | | | | | | | | | | | | 21,781 |
| 1974 | 5,446 | 637 | 6,083 | | | | | | | | | | | | | | 6,083 |
| 1975 | 18,324 | 937 | 19,261 | | | | | | | | | | | | | | 19,261 |
| 1976 | 15,814 | 94 | 15,908 | | | | | | | | | | | | | | 15,908 |
| 1977 | 8,678 | 532 * | 9,210 | | | | | 914 | 914 | | | 245 | | | | | 10,369 |
| 1978 | 11,767 | 712 | 12,479 | | | | | | | | | | | | | | 12,479 |
| 1979 | 9,572 | 712 | 10,284 | | | | | | | | | | | | | | 10,284 |
| 1980 | 8,347 | 746 | 9,093 | | | | | | | | | | | | | | 9,093 |
| 1981 | 6,423 | 148 | 6,571 | | | | | 147 | 147 | | | | | | | | 6,718 |
| 1982 | 3,734 | 247 | 3,981 | | | | | 43 | 43 | 875 | | | | 1,598 | 402 | 2,000 | 6,899 |
| 1983 | 14,437 | 547 ** | 14,984 | | | | | 105 | 105 | | | | | | | | 15,089 |
| 1984 | 6,205 | 335 ** | 6,540 | | 3,098 | 3,098 | | | | 200 | 400 | | 150 | | | | 10,388 |
| 1985 | 7,929 | 207 | 8,136 | | 1,863 | 1,863 | | 181 | 181 | | | | | | | | 10,180 |
| 1986 | 7,229 | 591 | 7,820 | | 284 | 284 | | 197 | 197 | | | | | | | | 8,301 |
| 1987 | 15,768 | 454 | 16,222 | | | | | 349 | 349 | | | | | | | | 16,571 |
| 1988 | 12,103 | 404 | 12,507 | | 658 | 658 | | 53 | 53 | | | | | | | | 13,218 |
| 1989 | 11,990 | 817 | 12,807 | | 0 | 0 | | 65 | 65 | | | | | | | | 12,872 |
| 1990 | 6,792 | 100 | 6,892 | | 1,094 | 1,094 | | 92 | 92 | | | | | | | | 8,078 |
| 1991 | 6,493 | 118 | 6,611 | | 1,491 | 1,491 | | 161 | 161 | | | | | | | | 8,263 |
| 1992 | 8,958 | 398 | 9,356 | | 431 | 431 | | 344 | 344 | | | | | | | | 10,131 |
| 1993 | 339 | 400 | 739 | | | | | 528 | 528 | | | | | | | | 1,267 |
| 1994 | 137 | 154 | 291 | | | | | 598 | 598 | | | | | | | | 889 |
| 1995 | – | 166 | 166 | | | | | 323 | 323 | | | | | | | | 489 |
| 1996 | – | 48 | 48 | | | | | 1,337 | 1,337 | | | | | | | | 1,385 |
| 1997 | – | | – | | | | | 4,578 | 4,578 | | | | | | | | 4,578 |
| 1998 | 38,239 a/ | | 38,239 | | 1,101 | 1,101 | | 3,079 | 3,079 | | | | | | | | 42,419 |
| 1999 | 8,683 b/ | | 8,683 | | | | | 7,075 | 7,075 | | | | | | | | 15,758 |
| 2000 | 8,632 a/ | | 8,632 | | 119 | 119 | | 4,194 | 4,194 | | | | | | | | 12,945 |
| 2001 | 18,351 a/ | | 18,351 | | 925 | 925 | | 3,327 | 3,327 | | | | | | | | 22,603 |
| 2002 | 36,004 a/ | | 36,004 | | 0 | 0 | | 2,669 | 2,669 | | | | | | | | 38,673 |
| 2003 | 5,346 a/ | | 5,346 | | 148 | 148 | | 2,797 | 2,797 | | | | | | | | 8,291 |
| 2004 | 8,824 a/ | | 8,824 | | 0 | 0 | | 5,040 | 5,040 | | | | | | | | 13,864 |
| [2005] | 9,493 | 77 | 9,570 | | 1,031 | 1,031 | | 6,434 | 6,434 | | | | | | | | 17,035 |
| [2006] | 14,168 a/ | | 14,168 | | 3,855 | 3,855 | | 5,111 | 5,111 | | | | | | | | 23,134 |

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY.

BLANK ENTRY INDICATES THAT TRIBUTARY WAS NOT SURVEYED, OR THAT NO ESTIMATE WAS MADE.

1/ Red Bluff Diversion Dam.
2/ Includes numbers of fish for tributaries where estimates were not made.
3/ Transferred to Coleman National Fish Hatchery from Keswick Dam (unless otherwise noted).
* Fish transferred from RBDD.
** Total fish transferred from both Keswick Dam and RBDD.
4/ Transferred to Tehama-Colusa Fish Facility from RBDD.

a/ Mainstem in-river estimates based on carcass surveys, all others based on Red Bluff Diversion Dam counts.

b/ Est[illegible] only for the area covered in the carcass survey. Other estimates based on carcass [illegible]ys were expanded using aerial redd counts.

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Native Anadromous Fish & Watershed Branch

GrandTab
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# WINTER-RUN CHINOOK SALMON: Sacramento-San Joaquin River System

| | SACRAMENTO RIVER SYSTEM | | | | | | | SAN JOAQUIN RIVER SYSTEM | TOTAL RUN FOR CENTRAL VALLEY | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mainstem Sacramento River | | | | | | | | | |
| | In-river Spawners | | | Hatchery Transfers 1/ | | Battle Creek 4/ | Total RUN for System 5/ | | | |
| YEAR | Upstream of RBDD 2/ | Downstream of RBDD 3/ | Total In-river | Coleman NFH | Livingston Stone NFH | | | Calaveras River | | YEAR |
| 1970 | 40,409 | | 40,409 | | | | 40,409 | | 40,409 | 1970 |
| 1971 | 53,089 | | 53,089 | | | | 53,089 | | 53,089 | 1971 |
| 1972 | 35,929 | | 35,929 | | | | 37,133 | | 37,133 | 1972 |
| 1973 | 22,651 | | 22,651 | | | | 24,079 | | 24,079 | 1973 |
| 1974 | 21,389 | | 21,389 | | | | 21,897 | | 21,897 | 1974 |
| 1975 | 22,579 | | 22,579 | | | | 23,430 | 500 | 23,930 | 1975 |
| 1976 | 33,029 | | 33,029 | | | | 35,096 | 500 | 35,596 | 1976 |
| 1977 | 16,470 | | 16,470 | | | | 17,214 | | 17,214 | 1977 |
| 1978 | 24,735 | | 24,735 | | | | 24,862 | 150 | 25,012 | 1978 |
| 1979 | 2,339 | | 2,339 | | | | 2,364 | | 2,364 | 1979 |
| 1980 | 1,142 | | 1,142 | | | | 1,156 | | 1,156 | 1980 |
| 1981 | 19,795 | 2,756 | 22,551 | | | | 22,797 | | 22,797 | 1981 |
| 1982 | 1,233 | 39 | 1,272 | | | | 1,281 | | 1,281 | 1982 |
| 1983 | 1,827 | | 1,827 | | | | 1,831 | | 1,831 | 1983 |
| 1984 | 2,662 | | 2,662 | | | | 2,663 | 100 | 2,763 | 1984 |
| 1985 | 3,686 | 1,445 | 5,131 | | | | 5,407 | | 5,407 | 1985 |
| 1986 | 2,566 | | 2,566 | | | | 2,596 | | 2,596 | 1986 |
| 1987 | 2,068 | 97 | 2,165 | | | | 2,185 | | 2,185 | 1987 |
| 1988 | 2,129 | 728 | 2,857 | | | | 2,878 | | 2,878 | 1988 |
| 1989 | 635 | 14 | 649 | 42 | | | 696 | | 696 | 1989 |
| 1990 | 384 | 28 | 411 | 14 | | | 429 | | 429 | 1990 |
| 1991 | 177 | 0 | 177 | 33 | | | 211 | | 211 | 1991 |
| 1992 | 1,159 | 44 | 1,203 | 34 | | | 1,240 | | 1,240 | 1992 |
| 1993 | 369 | 9 | 378 | | | | 387 | | 387 | 1993 |
| 1994 | 144 | 0 | 144 | 42 | | | 186 | | 186 | 1994 |
| 1995 | 1,159 | 7 | 1,166 | 43 | | 88 | 1,297 | | 1,297 | 1995 |
| 1996 | 1,012 | 0 | 1,012 | | | 325 | 1,337 | | 1,337 | 1996 |
| 1997 | 836 | 0 | 836 | | | 44 | 880 | | 880 | 1997 |
| 1998 | 2,831 | 72 | 2,903 | | 99 | | 3,002 | | 3,002 | 1998 |
| 1999 | 3,264 | 0 | 3,264 | | 24 | | 3,288 | | 3,288 | 1999 |
| 2000 | 1,263 | 0 | 1,263 | | 89 | | 1,352 | | 1,352 | 2000 |
| 2001 | 8,085 | 35 | 8,120 | | 104 | | 8,224 | | 8,224 | 2001 |
| 2002 | 7,348 | 12 | 7,360 | | 104 | | 7,464 | | 7,464 | 2002 |
| 2003 | 8,105 | 28 | 8,133 | | 85 | | 8,218 | | 8,218 | 2003 |
| 2004 | 7,784 | 0 | 7,784 | | 85 | | 7,869 | | 7,869 | 2004 |
| [2005] | 15,730 | 0 | 15,730 | | 109 | 0 | 15,839 | 0 | 15,839 | [2005] |
| [2006] | 17,153 | 52 | 17,205 | 5 | 93 | 31 | 17,334 | 0 | 17,334 | [2006] |

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY.

BLANK ENTRY INDICATES THAT MONITORING WAS NOT CONDUCTED, OR THAT NO ESTIMATE WAS MADE.

1/ Numbers of fish transferred from Red Bluff Diversion Dam (RBDD) and Keswick Dam to hatcheries.
2/ Upstream mainstem in-river estimates prior to 2001 were based on RBDD counts, subsequent estimates based on carcass surveys. Those numbers using RBDD data are
3/ Downstream mainstem numbers based on upstream estimates and redd distribution.
4/ Fish which passed upstream of Coleman NFH weir.
5/ Consists of those fish for in-river mainstem and tributaries, at hatcheries, and harvested by the sport fishery.

| SACR. RIVER MAINSTEM WINTER-RUN SALMON DATA 1/ | | | | |
|---|---|---|---|---|
| | | | Redd Distribution 2/ | |
| YEAR | Number of Fish Passing RBDD 3/ | Number of Fish Harvested 4/ | Upstream of RBDD | Downstream of RBDD |
| 1970 | 40,409 | | | |
| 1971 | 53,089 | | | |
| 1972 | 37,133 | 1,204 | | |
| 1973 | 24,079 | 1,428 | | |
| 1974 | 21,897 | 508 | | |
| 1975 | 23,430 | 851 | | |
| 1976 | 35,096 | 2,067 | | |
| 1977 | 17,214 | 744 | | |
| 1978 | 24,862 | 127 | | |
| 1979 | 2,364 | 25 | | |
| 1980 | 1,156 | 14 | | |
| 1981 | 20,041 | 246 | 87.8% | 12.2% |
| 1982 | 1,242 | 9 | 97.0% | 3.0% |
| 1983 | 1,831 | 4 | | |
| 1984 | 2,663 | 1 | | |
| 1985 | 3,962 | 276 | 71.8% | 28.2% |
| 1986 | 2,596 | 30 | | |
| 1987 | 2,088 | 20 | 95.5% | 4.5% |
| 1988 | 2,150 | 21 | 74.5% | 25.5% |
| 1989 | 682 | 5 | 97.9% | 2.1% |
| 1990 | 402 | 4 | 93.3% | 6.7% |
| 1991 | 211 | 1 | 100.0% | 0.0% |
| 1992 | 1,196 | 3 | 96.4% | 3.6% |
| 1993 | 378 | 9 | 97.7% | 2.3% |
| 1994 | 186 | 0 | 100.0% | 0.0% |
| 1995 | 1,290 | 0 | 99.4% | 0.6% |
| 1996 | 1,337 | 0 | 100.0% | 0.0% |
| 1997 | 880 | 0 | 100.0% | 0.0% |
| 1998 | 2,930 | 0 | 97.5% | 2.5% |
| 1999 | 3,288 | 0 | 100.0% | 0.0% |
| 2000 | 1,352 | 0 | 100.0% | 0.0% |
| 2001 | 5,499 | 0 | 99.6% | 0.4% |
| 2002 | 9,157 | 0 | 99.8% | 0.2% |
| 2003 | 9,724 | 0 | 99.7% | 0.3% |
| 2004 | 7,192 | 0 | 100.0% | 0.0% |
| [2005] | 5,299 | 0 | 100.0% | 0.0% |
| [2006] | 7,415 | 0 | 99.7% | 0.3% |

1/ Data used (when appropriate) to determine estimates for mainstem in-river salmon.
2/ Based on aerial surveys of mainstem.
3/ Estimated from fish counts at Red Bluff Diversion Dam (RBDD).
4/ Estiamted fish caught in the sport fishery upstream of RBDD. After 1995, it was assumed that no fish were harvested due to an angling closure for winter-run salmon.

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Native Anadromous Fish & Watershed Branch

GrandTab
Updated: 20-Aug-2[illegible]

# SPRING-RUN CHINOOK SALMON POPULATIONS: Sacramento-San Joaquin River System

| YEAR | Sacramento River Mainstem: Upstr. of RBDD 1/ | Sacramento River Mainstem: Dnstr. of RBDD | Sacramento River Mainstem: TOTAL | Battle Creek | Clear Creek | Cotton-wood Cr. | Antelope Cr. | Mill Cr. | Thomes Cr. | Deer Cr. | Big Chico Cr. | Butte Cr. | Feather River: In-river | Feather River: Hatchery | Feather River: TOTAL | Yuba R. | Calaveras R. | TOTAL for RUN | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1960 | a/ | | | | | | | 2,368 | | | | 8,700 | a/ | | | | | 11,068 | 1960 |
| 1961 | a/ | | | | | | | 1,245 | | | | 3,082 | | | | | | 4,327 | 1961 |
| 1962 | a/ | | | | | | | 1,692 | | | 200 | 1,750 | | | | | | 3,642 | 1962 |
| 1963 | a/ | | | | 0 | | | 1,315 | | 2,302 | 500 | 6,100 | 600 | | 600 | | | 10,817 | 1963 |
| 1964 | a/ | | | | 0 | | | 1,539 | | 2,874 | 100 | 600 | 2,908 b/ | | 2,908 | | | 8,021 | 1964 |
| 1965 | a/ | | | | 0 | | | | | | 50 | 1,000 | 738 b/ | | 738 | | | 1,788 | 1965 |
| 1966 | a/ | | | | 0 | | | | | | 50 | 80 | 297 b/ | | 297 | | | 427 | 1966 |
| 1967 | a/ | | | | | | | | | | 150 | 180 | | 146 | 146 | | | 476 | 1967 |
| 1968 | a/ | | | | 0 | | | | | | 175 | 280 | | 208 | 208 | | | 663 | 1968 |
| 1969 | 20,000 | | 20,000 | | 0 | | | | | | 200 | 830 | | 348 | 348 | | | 21,378 | 1969 |
| 1970 | 3,652 | | 3,652 | | | | | 1,500 | | 2,000 | | 285 | | 235 | 235 | | | 7,672 | 1970 |
| 1971 | 5,830 | | 5,830 | | | | | 1,000 | | 1,500 | 0 | 470 | | 481 | 481 | | | 9,281 | 1971 |
| 1972 | 7,038 | | 7,038 | | | | | 500 | | 400 | | 150 | | 256 | 256 | | 500 | 8,844 | 1972 |
| 1973 | 7,175 | | 7,175 | | | | | 1,700 | | 2,000 | 50 | 300 | | 205 | 205 | | | 11,430 | 1973 |
| 1974 | 3,800 | | 3,800 | | | 3 | | 1,500 | | 3,500 | 100 | 150 | | 198 | 198 | | | 9,251 | 1974 |
| 1975 | 10,234 | | 10,234 | | | 3 | | 3,500 | | 8,500 | | 650 | | 691 | 691 | | | 23,578 | 1975 |
| 1976 | 25,095 | | 25,095 | | | | | | | | | 46 | | 699 | 699 | | | 25,840 | 1976 |
| 1977 | 11,545 | | 11,545 | | | | | 460 | | 340 | 100 | 100 | | 185 | 185 | | | 12,730 | 1977 |
| 1978 | 5,669 | | 5,669 | | | | | 925 | | 1,200 | | 128 | 2 | 202 | 204 | | | 8,126 | 1978 |
| 1979 | 2,856 | | 2,856 | | | | | | | | | 10 | | 250 | 250 | | | 3,116 | 1979 |
| 1980 | 9,363 | 6 c/ | 9,369 | | | | | 500 | | 1,500 | | 226 | 400 | 269 | 669 | 200 | | 12,464 | 1980 |
| 1981 | 20,655 | | 20,655 | | | | | | | | | 250 | 531 | 469 | 1,000 | 200 | | 22,105 | 1981 |
| 1982 | 23,156 | | 23,156 | | | | | 700 | | 1,500 | | 534 | 90 | 1,910 | 2,000 | | | 27,890 | 1982 |
| 1983 | 3,854 | 1,793 | 5,647 | | | | 59 | | | 500 | | 50 | | 1,702 | 1,702 | | | 7,958 | 1983 |
| 1984 | 7,823 | | 7,823 | | | | | 191 | | | 0 | 23 | | 1,562 | 1,562 | | | 9,599 | 1984 |
| 1985 | 10,200 | 2,713 | 12,913 | | | | | 121 | | 301 | 0 | 254 | | 1,632 | 1,632 | | | 15,221 | 1985 |
| 1986 | 15,948 | 6,110 | 22,058 | | | | | 291 | | 543 | | 1,371 | | 1,433 | 1,433 | | | 25,696 | 1986 |
| 1987 | 10,911 | 1,460 | 12,371 | | | | | 90 | | 200 | | 14 | | 1,213 | 1,213 | | | 13,888 | 1987 |
| 1988 | 9,601 | 266 | 9,867 | | | | | 572 | | 371 | | 1,290 | | 6,833 | 6,833 | | | 18,933 | 1988 |
| 1989 | 5,131 | 0 | 5,131 | 7 | | 0 | | 563 | | 84 | | 1,300 | | 5,078 | 5,078 | | | 12,163 | 1989 |
| 1990 | 3,896 | 302 | 4,198 | 2 | | | | 844 | | 496 | | 250 | | 1,893 | 1,893 | | | 7,683 | 1990 |
| 1991 | 766 | 59 | 825 | | | 1 | | 319 | | 479 | | | | 4,303 | 4,303 | | | 5,927 | 1991 |
| 1992 | 371 | 0 | 371 | | | | 0 | 237 | | 209 | | 730 | | 1,497 | 1,497 | | | 3,044 | 1992 |
| 1993 | 391 | 0 | 391 | | 1 | | 3 | 61 | | 259 | 38 | 650 | | 4,672 | 4,672 | | | 6,075 | 1993 |
| 1994 | 862 | 0 | 862 | | 0 | | 0 | 723 | | 485 | 2 | 474 | | 3,641 | 3,641 | | | 6,187 | 1994 |
| 1995 | 349 | 77 | 426 | 66 | 2 | 8 | 7 | 320 | | 1,295 | 200 | 7,500 | | 5,414 | 5,414 | | | 15,238 | 1995 |
| 1996 | 378 | | 378 | 34 | | 6 | 1 | 253 | | 614 | 2 | 1,413 | | 6,381 | 6,381 | | | 9,082 | 1996 |
| 1997 | 126 | 2 | 128 | | | | 0 | 202 | | 466 | 2 | 635 | | 3,653 | 3,653 | | | 5,086 | 1997 |
| 1998 | 1,115 | 0 | 1,115 | | 47 | 477 | 154 | 424 | 1 | 1,879 | 369 | 20,259 | | 6,746 | 6,746 | | | 31,471 | 1998 |
| 1999 | | | | 70 | | 102 | 40 | 560 | | 1,591 | 27 | 3,679 | | 3,731 | 3,731 | | | 9,800 | 1999 |
| 2000 | 71 | 0 | 71 | 40 | 19 | 122 | 9 | 544 | | 637 | 27 | 4,118 | | 3,657 | 3,657 | | | 9,244 | 2000 |
| 2001 | 711 | 25 | 736 | | | 245 | 8 | 1,100 | | 1,622 | 39 | 9,605 | | 4,135 | 4,135 | 108 | | 17,598 | 2001 |
| 2002 | 273 | 0 | 273 | 144 | 66 | 125 | 46 | 1,594 | 2 | 2,185 | 0 | 8,785 | | 4,189 | 4,189 | | | 17,409 | 2002 |
| 2003 | | 0 | 0 | 94 | 25 | 73 | 46 | 1,426 | | 2,759 | 81 | 4,398 | | 8,662 | 8,662 | | | 17,564 | 2003 |
| 2004 | 394 | 0 | 394 | 66 | 98 | 17 | 3 | 998 | | 804 | 0 | 7,390 | | 4,212 | 4,212 | | | 13,982 | 2004 |
| [2005] | 0 | 30 | 30 | 80 | 69 | 47 | 82 | 1,150 | | 2,239 | 37 | 10,625 | | 1,771 | 1,771 | | | 16,130 | [2005] |
| [2006] | 0 | 0 | 0 | 177 | 70 | 55 | 102 | 1,002 | | 2,432 | 299 | 4,579 | | 1,952 | 1,952 | | | 10,668 | [2006] |

DATA FOR [YEARS IN BRACKETS] ARE PRELIMINARY.

BLANK ENTRY INDICATES THAT TRIBUTARY WAS NOT SURVEYED, OR THAT NO ESTIMATE WAS MADE.

1/ Red Bluff Diversion Dam.

a/ Estimated numbers are included with fall-run fish.
b/ Fish were transferred to upstream of Oroville Dam.
c/ Only fish taken into Tehama-Colusa Fish Facility.

Attachment 20

SAN FRANCISCO Estuary & Watershed SCIENCE

Volume 4, Issue 3, Article 2
2006

# CENTRAL VALLEY SALMON

## A Perspective on Chinook and Steelhead in the Central Valley of California

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# CHAPTER 10

# THE ESTUARY

*We must remember that in the past 120 years, the Delta has changed from a vast tidal marsh to a series of 40 large flat-farmed islands. The old tidal creek channels have been dredged into some 900 miles of navigable waterways. ... Surprisingly enough, a significant wildlife resource remains. It is a far different resource, made up to a very great extent of introduced species dependent on an unnatural environment that man has been changing drastically for a hundred years.*

*Resources Agency of California (1964:1)*

*The most efficient and effective way to increase juvenile abundance would be to increase survival during outmigration to the ocean, particularly during passage through the Sacramento-San Joaquin Delta. ... Any improvements in delta survival would benefit natural production at a life stage when natural mortality is not density dependent and would result in a commensurate increase in adults if ocean survival is independent of freshwater survival.* *SRFCRT 1994:1*

*The notion of independent limiting factors to salmon production stems from a traditional agricultural approach to resource management. From this perspective, the estuary was viewed as a hazardous environment where numerous predators or competitors must be controlled to ensure efficient salmon production. This perspective provided little information about the estuarine habitats that salmon need or the processes that link freshwater, estuarine, and marine habitats. A fundamental impediment to salmon and estuary recovery, therefore, is the lack of an explicit conceptual framework to explain the evolutionary and ecological requirements of diverse salmon populations.*

*Bottom et al. 2005:iv*

Many if not most salmon studies in the Central Valley in recent decades concern the passage of larger juveniles through the Delta, or the effects on salmon of the Delta pumps. Most of these studies reflect the view, expressed in the quotation above by the Sacramento River Fall Chinook Review Team, that for salmon the Delta is something to be got through. This view is widespread (Bottom et al. 2005), and in the Central Valley probably has been reinforced by the extensive modification of the Delta and the loss of tidal wetlands there. In contrast to the Delta, there has been little study of juvenile salmon in the bays until a recent effort by NOAA Fisheries that is still in progress, although results from the first year are described in MacFarlane and Norton (2002). This chapter reviews studies of the use of estuaries elsewhere by Chinook and steelhead, and then studies their occurrence of the Delta and of their survival passing through it. There is also information on the growth of juvenile Chinook in the estuary and the timing of their migrations through it in chapters 5 and 6.

## The use of estuaries by Chinook and steelhead

The importance of estuaries for Chinook salmon has long been recognized. In the first major publication on salmon in the Central Valley, Rutter (1904; 71) observed that "The quinnat

[Chinook] salmon is found throughout the Pacific coast from Monterey Bay northward, but is less abundant north of Puget Sound. At spawning time it frequents the larger streams, especially those with estuaries." Rutter's associate, N. B. Scofield, monitored the movement of juvenile Chinook into the Delta at Georgiana Slough from January through May, 1899, as discussed in Ch. 6. Rutter knew that very young fry were sometimes found in brackish estuaries, and learned by experiments at the "Hopkins Seaside Laboratory" that even alevins tolerate brackish water: at six days post-hatch alevins can live in 25% seawater, and at 40 days in 50% seawater (Rutter 1904). Rich (1920:51) found from studies of scales of juvenile Chinook in the Columbia River that "The effect of migration into the brackish water of estuary is to decidedly stimulate the growth."

Estuaries are highly variable, as are Chinook life history patterns, so it is not surprising that the use of estuaries by Chinook is also highly variable, as found by Rich (1920) and subsequent workers. Generally, it appears that the importance of estuaries to Chinook varies inversely with the size of the fish reaching the estuary; stream-type Chinook that rear for a year in freshwater spend little time there, but ocean-type Chinook that migrate to the estuary directly after emergence depend on the estuary for rearing habitat, and may spend considerable time there (Healey 1991). For example, Healey (1980) estimated that fry migrants stay as long as 60 days in the Nanaimo River estuary, and tagged hatchery fry remained in the Delta for up to 64 days (Kjelson et al. 1982). Fry migrants initially tend to occupy shallow habitats, often moving far up into tidal wetlands with high tides, but move into deeper water as they grow; Chinook that rear in the river for several months before emigrating rapidly also occupy deeper water (Healey 1991). MacFarlane and Norton (2002) reported that juveniles sampled from April to mid-June took on average around 40 days to migrate through the bays, suggesting a total residence time in the estuary of up to 100 days.

As described in more detail in Ch. 5, most fall-run juveniles in the Central Valley begin migrating toward the lower rivers or the Estuary in January, February or March, shortly after they emerge from the gravel, when they are still less than 50 mm long; however, a considerable number rear near the spawning areas for one to three months before migrating, typically in April and May and at more than 60 mm. A few emigrate in the fall or winter, or in spring as yearlings. Most spring-run in the Central Valley follow a juvenile life-history pattern similar to that of fall-run, although some follow the typical stream-type life history pattern. The timing of migration among winter-run, late fall-run, and yearling spring-run is less clear, because the size-at-date method for distinguishing the runs is unreliable in the Delta (Hedgecock 2002), and they are otherwise distinguishable only by genetic analyses. Generally, however, there are larger (>~100 mm) juveniles moving into the Delta from fall through February or March. There is very little information on the extent to which these fish rear in the Delta, or on the extent to which doing so affects their survival.

Bottom et al. (2002) recently summarized the importance of estuaries for juvenile Chinook. There are enough differences between the Columbia estuary and the San Francisco Estuary that

various details do not apply, but there are enough similarities to make the summary and literature review quite relevant:

> More than just a simple corridor for salmon migration, the Columbia River estuary functions as an important transition environment, where individuals should have the opportunity to gradually adapt to salt water, and as a nursery ground, where many young salmon feed and grow to sizes that may increase their chances of surviving in the ocean (Reimers 1973; Simenstad et al. 1982; Thorpe 1994). Juvenile salmon are found in the estuary all months of the year, as different species, size classes, and life-history types continually move downstream and enter tidal waters from multiple upstream sources. The timing and duration of estuarine residence varies widely among salmon species and life-history types with species (Groot and Margolis 1991). Chinook salmon, (*O. tshawytscha*), which has the greatest diversity of juvenile life histories among all Pacific salmon (Healey 1991; Wissmar and Simenstad 1998), has the most varied patterns of estuarine use. Healey (1982) proposed that Chinook are the most estuarine dependent salmonid species since virtually all life-history types spend some time feeding and growing in estuaries, and (ocean-type) fry migrants may depend entirely on the estuary for nursery habitats. ...
>
> The movements of juvenile salmon and their patterns of habitat use within estuaries are size related. Chinook salmon and chum salmon subyearlings (fry) usually occupy shallow, nearshore habitats, including salt marshes, tidal creeks, and intertidal flats (Levy and Northcote 1982; Myers and Horton 1982; Simenstad et al. 1982; Levings et al. 1986). As subyearlings grow to fingerling and smolt stages, their distribution typically shifts toward deeper habitats farther from the shoreline(Healey 1982; 1991; Myers and Horton 1982). In the Columbia River estuary, McCabe et al. (1986) reported that subyearling Chinook salmon in shallow intertidal habitats were smaller than subyearlings captured in deeper pelagic areas. Large yearling migrants, on the other hand, may spend relatively little time in shallow-water habitat. A 1980-81 survey of the Columbia River estuary, for example, found most yearling Chinook salmon at deeper channel sites rather than at intertidal sites sampled near shore (Bottom et al. 1984). Thus, the occurrence of small subyearling salmon, including those life-history-history types that stay in the estuary for the longest periods, may be closely linked to the availability of certain shallow-water habitats.
>
> Emergent marshes, forested wetlands, and dendritic tidal channel networks may be particularly important to small salmon because they are (1) areas of high secondary production of insect and other invertebrate prey; (2) sources and sinks for detritus; and (3) places where complex structure provides refuge from predators (e.g., Levy and Northcote 1982; McIvor and Odum 1988; Gray et al. In press). ...

Although there has been extensive monitoring of the occurrence of juvenile salmon and steelhead in the Delta, and good evidence that Chinook fry rear there, there has been relatively little study of the actual use of the habitat by those fishes (Brown 2003). One exception is the BREACH studies (http://depts.washington.edu/calfed/breachii.htm). Generally, the results for Chinook are consistent with the studies of more northern estuaries reviewed above (L. Grimaldo, CDWR, pers.comm. 2003): small juveniles (< 60 mm) were collected from January to April,

with a peak in March. Most Chinook were collected in open water rather than among submerged aquatic vegetation, and their stomachs contained mainly larval and pupal chironomids (midges) and amphipods.

It appears that juvenile Chinook make less use of the marshes around the edges of Suisun and San Pablo bays than might be expected from the literature. In a review of the use of estuaries in Washington by Pacific salmon, Simenstad et al. (1982:352) noted that "Subyearlings and fry occur mainly in salt marshes where these habitats are available. However, mudflat, foreshore areas can be utilized for some time by larger subyearlings before they move into neritic habitats (Stober et al. 1973; Simenstad and Eggers 1981; Congleton et al. 1981)." Some of the Kjelson et al. (1982) West Delta sites were in brackish areas, and some juvenile Chinook were captured there, particularly in the wet year 1980, when juveniles were captured in San Pablo Bay and central San Francisco Bay as well. The IEP regularly captures juveniles at seine sampling stations around the edge of the bays, particularly in wet years, but the numbers are small (SSJEFRO 2003). Efforts to collect juvenile Chinook with beach seines for the work described in MacFarlane and Norton (2002) were largely unsuccessful (Bruce MacFarlane, NOAA Fisheries, pers.comm., 2003). However, Chinook fry (< 50 mm) are captured by the IEP trawl sampling at Chipps Island in wet years, and fry were found in near-shore habitats near Pittsburg in wet years during studies of the effects of the plume of warm cooling water from a large power plant (C. Hanson, Hanson Environmental, pers.comm.). As summarized by Kjelson et al. (1982:407): "In the Sacramento-San Joaquin system most estuarine rearing occurs in the freshwater Delta supplemented by fry rearing in the brackish bays during high runoff years."

The scant evidence of use of tidal wetlands and flats around the margins of the bays in drier years is something of an enigma, and may reflect a recent change in Chinook behavior. Considerable numbers of small (< 50 mm) Chinook were captured in a fyke trap at Martinez, in the strait between Suisun and San Pablo bays, in March and early April 1939, a dry year (Hatton 1940; Figure 6-29), and a 1966 report referred to "the proven heavy use of the mud flats of Suisun and Honker Bays by salmon and steelhead" (Delisle 1966:59).[57] Alternatively, the apparent low densities of juvenile Chinook around the bays may reflect the large area potentially available to them. The extent and circumstances under which juvenile Chinook make significant use of these brackish tidal areas has implications for the value for Chinook of wetland restoration around the bays, and deserves more attention. Repeating Hatton and Clark's trapping at Martinez would be an initial step.

**Studies of the Delta**

Erkkila et al. (1950) investigated the spatial distribution of juvenile Chinook within the Delta at 25 stations in April to July 1948 and in late February to July 1949, using a tow net with a 1.5 m (5 ft) circular opening, fished just below the surface (e.g., Figure 10-1). Although their

[57] Unfortunately, Delise (1966) did not provide a citation for his statement regarding heavy use of mud flats by Chinook and steelhead. However, he also stated that use of mud flats around the rest of the bay was unknown, so presumably he had some study in mind. Don Fry, a CDFG salmon biologist, helped with this report, and the statement about Suisun and Honker bays may reflect his knowledge.

catches seem too small to allow great confidence in the details of their results, they did show persuasively that Chinook from the Sacramento River were widely distributed through the Delta and remained there for some time. Catches peaked in February 1949, but remained fairly high until early June. Average size was steady through most of March, but increased rapidly in early April and again in late June, although the number of fish was very low by then (Figure 10-2). Juvenile Chinook from the San Joaquin River did not appear until early April in both 1948 and 1949, which Erkkila et al. (1950) attributed to the low flow in the river. They reported that movement of fish into the Delta was often but not always associated with pulses of flow, and that juveniles were gone from the Delta by the time the water warmed to about 24°C in both years.

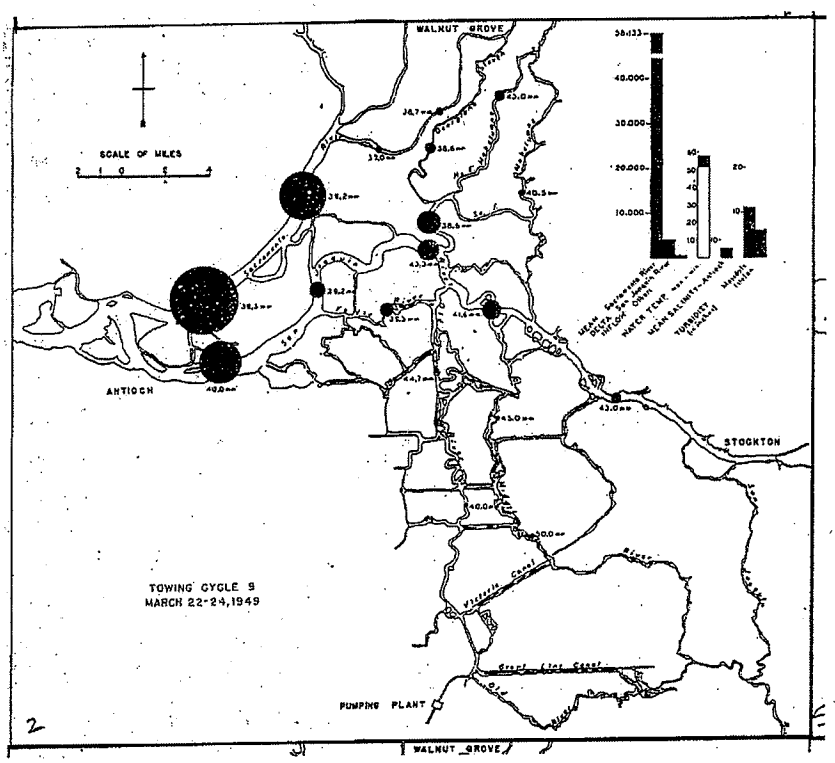



Figure 10-1. A panel from Figure 4 in Erkkila et al. (1950), depicting the estimated spatial distribution of juvenile Chinook in the Delta during the March 22-24, 1949 towing cycle. Areas of the circles are proportional to estimated abundance at the stations; the inset bar graphs show Delta inflow from the Sacramento, San Joaquin, and Mokelumne rivers, minimum and maximum water temperatures, mean salinity, and turbidity at Mossdale and Isleton.

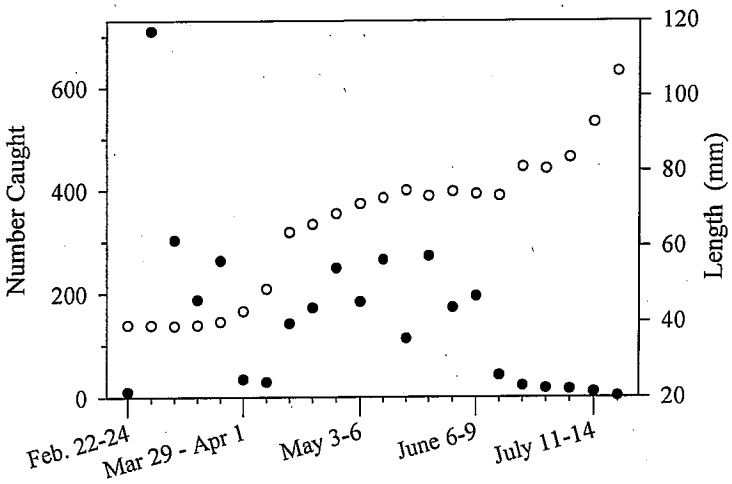



Figure 10-2. Size and abundance of juvenile Chinook in the Delta. Number (filled symbols) and mean fork length (open symbols) of juvenile Chinook captured in the Delta by Erkkila et al. (1950), in 1949, summed over 25 towing stations. Note that the mean length did not increase until late March.

Beach seines (15 x 1.2 m) were used in a subsequent study of the abundance and distribution of juvenile Chinook in the Delta (Kjelson et al. 1982; Figure 10-3); average catches peaked in February or March, and dropped off sharply in April. Monthly average lengths increased most rapidly from April to May, but the number of fish captured decreased sharply over the same period (Figure 10-4). Again, increased catches were associated with pulses of inflow. In diurnal sampling catches were higher during the day than at night, suggesting that the fish moved offshore then.

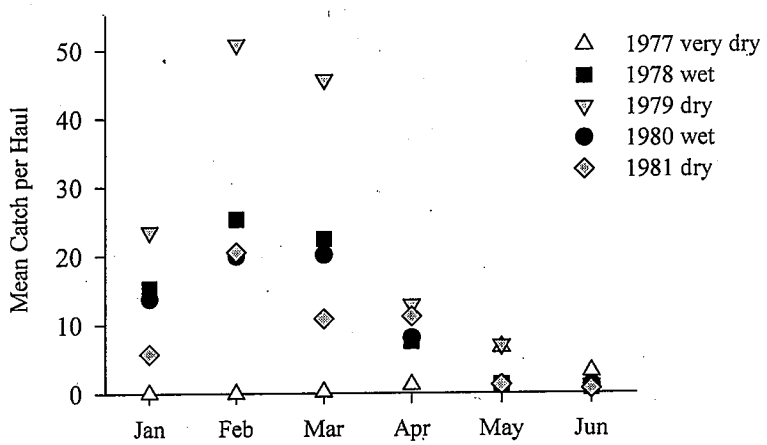



Figure 10-3. Mean monthly catch per haul of juvenile Chinook collected by beach seine in the Northern Delta in five years. Within months, catches were highly variable (average coefficient of variation 208%). Data from Kjelson et al. 1982.

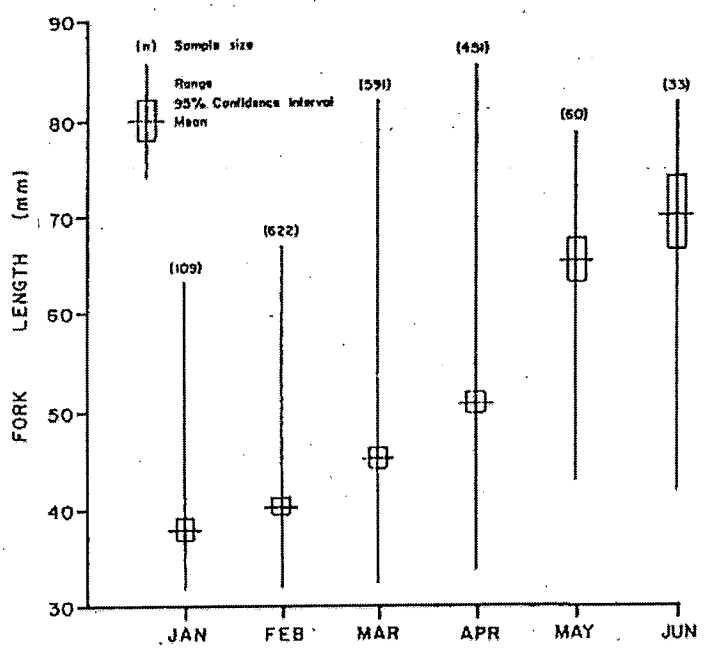
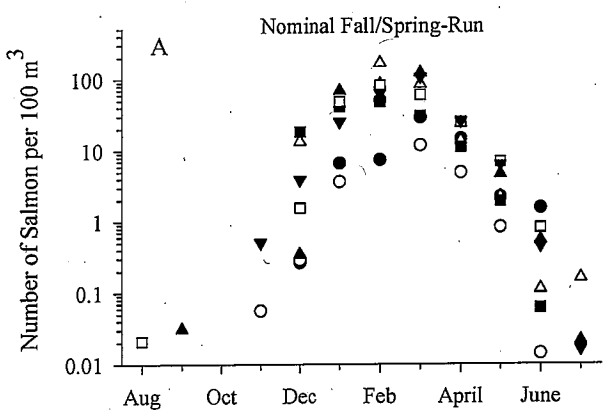
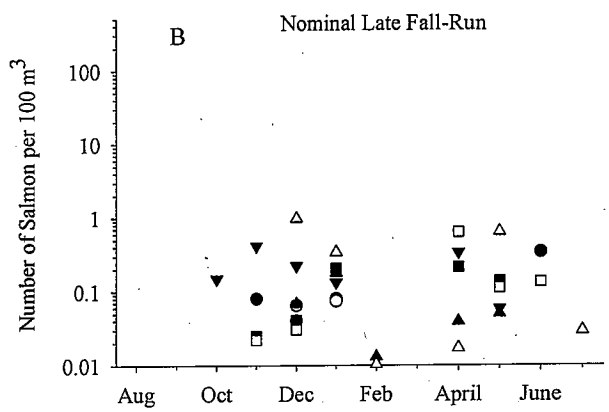



Figure 10-4. Mean size with 95% confidence intervals and range in sizes of 1,866 juvenile Chinook captured with beach seines in the northern Delta between 1978 and 1981. Copied from Kjelson et al. (1982).

Sampling with beach seines in the estuary has been continued by the IEP at ~ 40 stations from Sacramento and Stockton to San Francisco Bay. Summary data from this sampling from 1992-93 to 1998-99 have been reported in SSJEFRO (2003), with fish allocated to runs according to size at date criteria, except that spring and fall-run are reported together because they overlap in size.

Spring/fall-run are most abundant in the Delta in late winter and early spring, as fry, but are captured in significant numbers as larger juveniles in late spring as well, and in small numbers as larger juveniles in late summer and fall (Figure 10-5 ). The beach seines presumably are less effective for the larger juveniles that tend to occupy deeper water and are better able to escape the net, so the seasonal differences probably are somewhat less extreme than figures 10-3 and 10-5 suggest. Similarly, the nominal late fall-run captured in fall and winter are much larger than those captured in the spring, and probably are relatively more abundant than the seine data suggest.



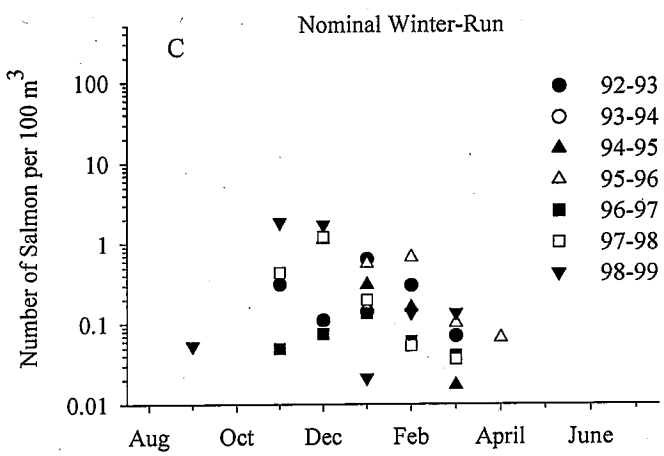




Figure 10-5. Average abundance of juvenile Chinook at beach seine sites in the Delta, for 1992-92 to 1998-99: A, nominal fall or spring-run; B, nominal ate fall-run; C, nominal winter-run. Data from SSJEFRO (2003).

Only one haul is taken at each station per sampling cycle, and the catches at individual sites are extremely variable (e.g., Figure 10-6), presumably because the fish occur largely in schools, so the data show only general patterns of temporal distribution. Similarly, it is not clear how well

the stations represent the areas in which they occur. For example, should we believe that there are few juvenile Chinook around the mouth of Steamboat Slough (Figure 10-7), or do the low catches reflect the particular site that is sampled? Nevertheless, the data do show, for example, that on an annual basis the January to March seine catch in the North Delta increases with the mean February flow in the Sacramento River ($r^2 = 0.69$; Brandes and McLain 2001).

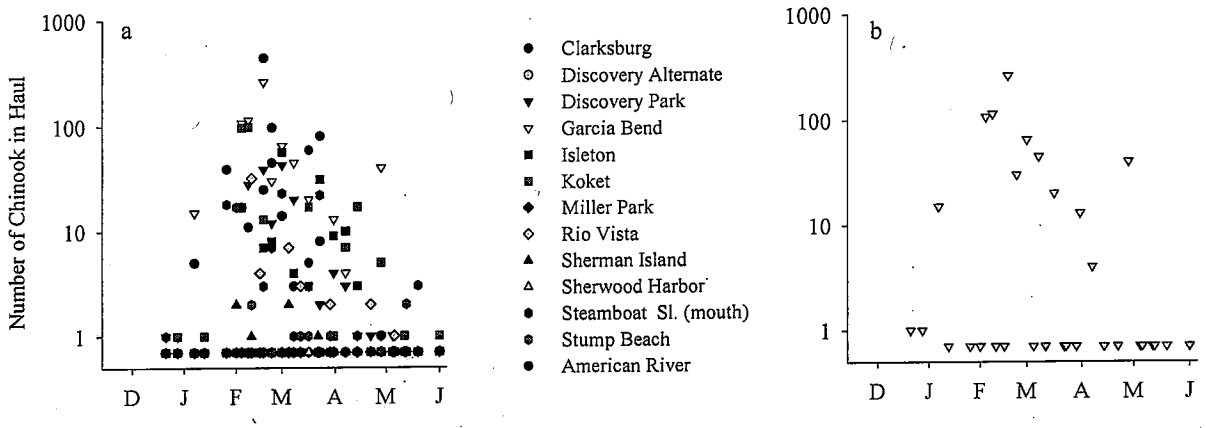
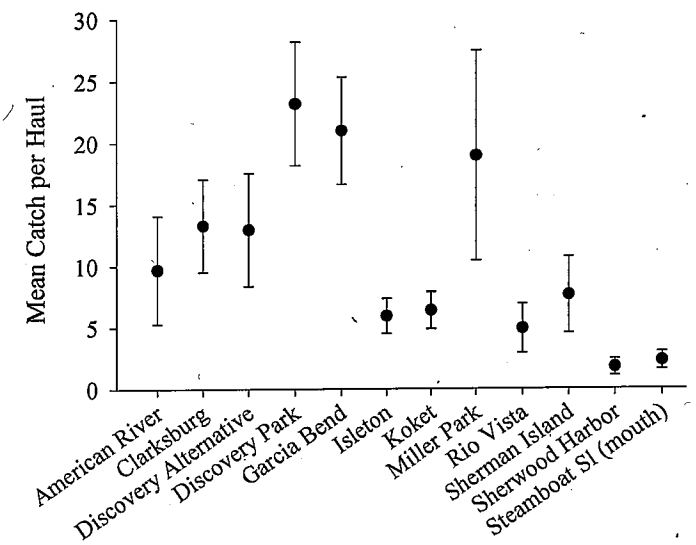



Figure 10-6. Catch per haul of juvenile Chinook in 1993-1994 at (a) 13 seine stations in the North Delta and at (b) one of the stations, Garcia Bend. Catches are extremely variable; note log scale (except that symbols at bottom show catches of zero).

Figure 10-7. Mean catch per haul for 12 sampling stations in the North Delta, 1993-2002. Bars show 95% confidence intervals. Data from IEP.




Sampling also occurs at the CVP and SWP diversion facilities at the southern edge of the Delta, where fish are diverted by screens into holding tanks and trucked to the western Delta, and samples are counted and measured (Brown and Greene 1992). The fish sampled are neither a random nor a uniform sample of the fish that make their way to the diversions, since a smaller proportion is sampled when density is high, and the efficiency of the screens varies with factors such as the rate of diversion (Brown and Greene 1992; Hedgecock 2002). Moreover, many fish

may be consumed by predators as they approach the facilities. Nevertheless, it seems likely that the salvage data reasonably reflect major patterns regarding the time of year and conditions under which fish arrive or do not arrive at the diversions. Unfortunately, this source of information has not yet been fully exploited.

The general pattern of arrivals at the diversion facilities is fairly clear (Figure 10-8). Larger (>~ 80 mm) juvenile Chinook arrive from late summer to spring. Small juveniles begin to arrive in winter, and do so with little increase in size until sometime in March. Their average size then increases rapidly for about a month, from < 50 mm to > ~80 mm, and then levels off until July, when salvage of Chinook essentially ends.

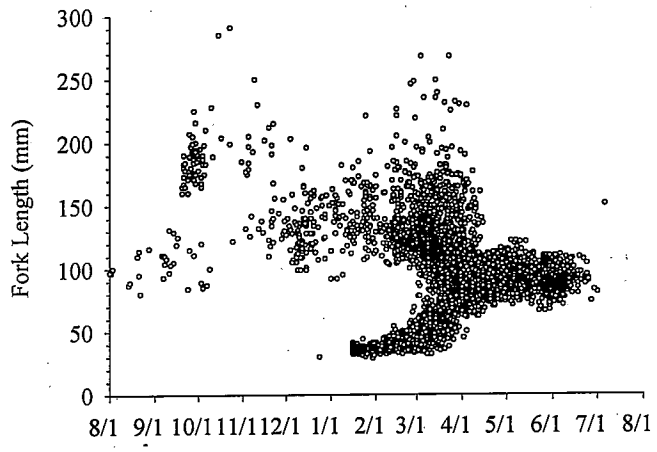



Figure 10-8. Juvenile Chinook at the Delta diversions; size at date of 6,752 juvenile Chinook sampled at the CVP and SWP diversion facilities in the Delta from August 1995 through July 2001. Data from Hedgecock (2002).

Flow apparently affects the timing with which juvenile fall and spring-run appear at the pumps. In a wet year (2000), young-of-the-year Chinook appeared at the pumps in mid-February, flowing a sharp increase in Delta inflow; however, in 2001, a dry year, few fish were sampled until late March (Figure 10-9).

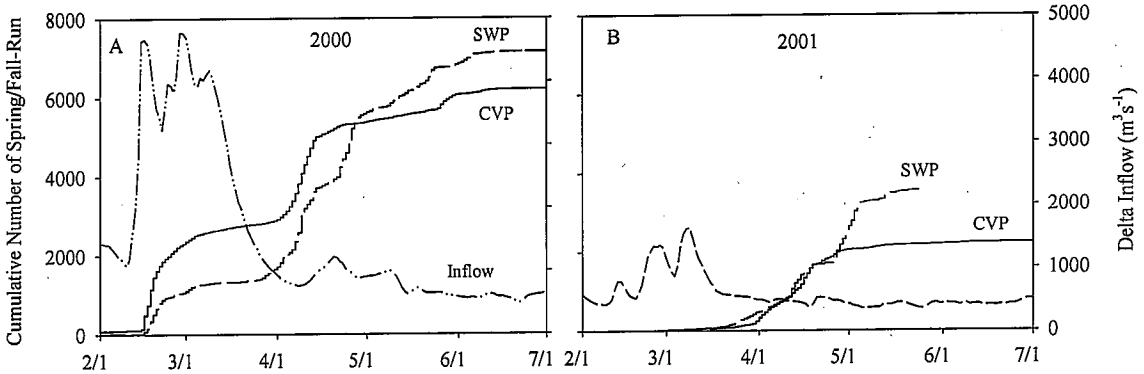



Figure 10-9. Unmarked juvenile spring or fall Chinook sampled at the CVP and SWP diversions in 2000 (A) and 2001 (B). Dashed lines show total inflow to the Delta. Fish appeared at the diversion facilities shortly after a rise in Delta inflow in February 2000. The numbers sampled are not expanded and do not represent the total numbers collected at the pumps (see text), but should reflect major patterns in the arrival of fish at the diversions. Data from the IEP database.

The rate at which juvenile Chinook appear in the samples is affected by the rate of pumping, but the relationship does not appear to be simple; for example, CVP pumping was steady though February and most of March, 2000, then dropped briefly in late March and resumed in early April (Figure 10-10). The peaks in sampling occurred in late February and early April.

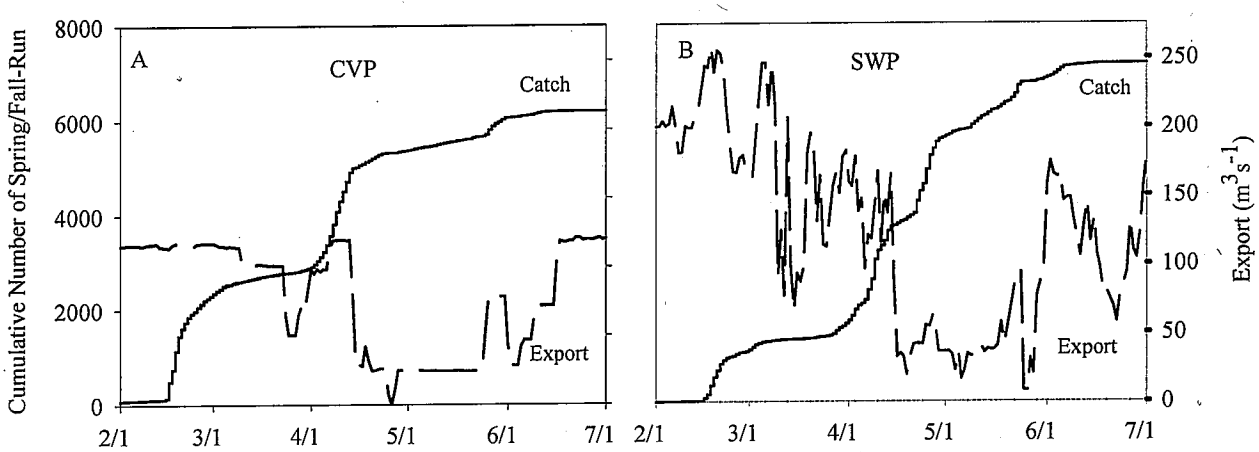



Figure 10-10. Cumulative number of unmarked juvenile spring and fall-run Chinook sampled at the CVP and SWP pumps in January through June of 2000 (solid lines), and exports for the same period (dashed lines). Data from the IEP database.

Besides arriving at the diversion facilities later in 2001 than in 2000, age 0 Chinook were also smaller by ~5 mm in late spring, and they were about~ 2 mm larger at the SWP diversion than at the CVP diversion in both years (Figure 10-11). Such year to year variation in size at date may provide a useful index of growth opportunity in fresh water. This should be explored. It would also be useful to look for relations between increases and decreases in the number of fish sampled at the diversions and environmental variables, such as increases in Delta inflow, and in the number of fish collected in other sampling efforts such as the Chipps Island trawl. The objective should be better understanding of the behavior of the fish, as well as better predictions of their arrival at the diversions.

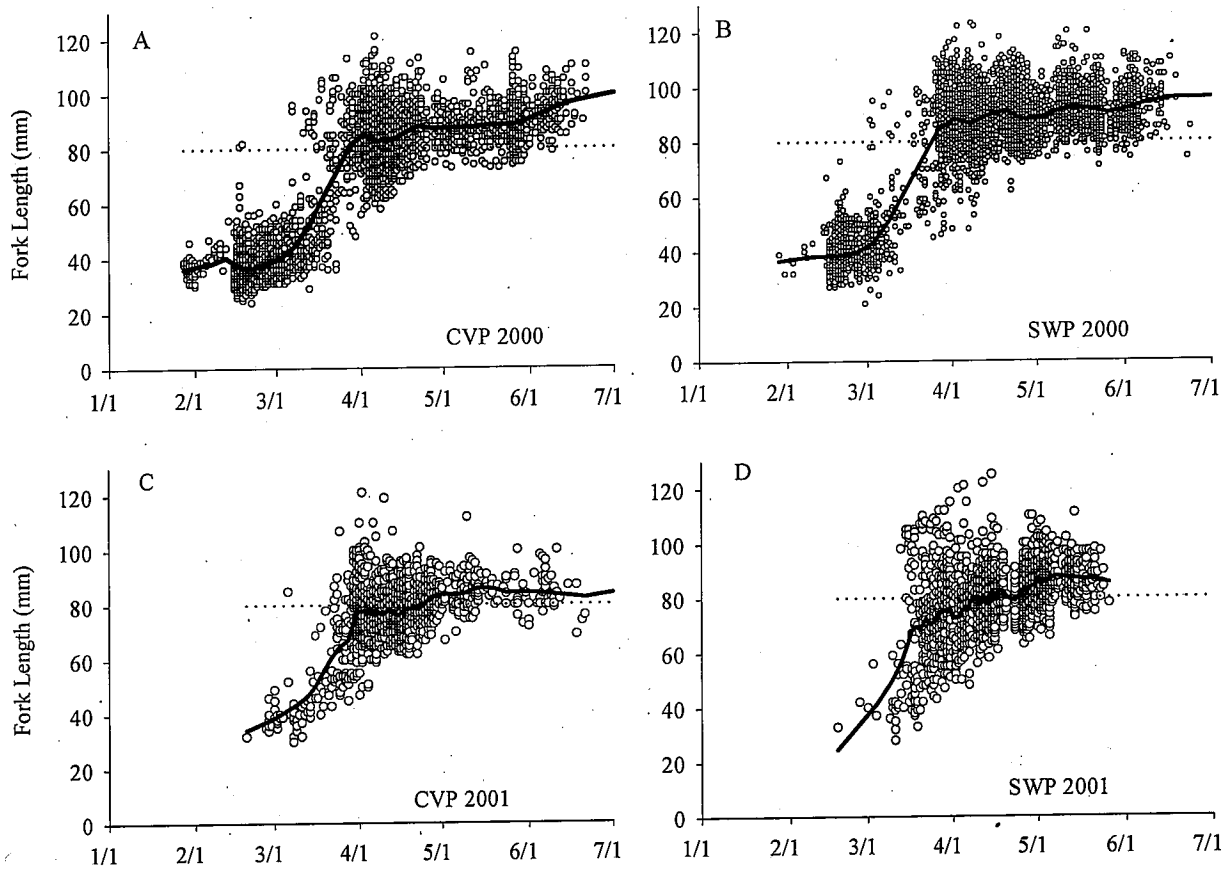



Figure 10-11. Lengths of unmarked fall and spring Chinook sampled at CVP and SWP diversion facilities in 2000, a wet year (A and B), and 2001, a dry year (C and D). Trend lines fit by LOWESS; almost all the change in length occurred March. Data from the IEP data bank.

Even when the numbers of fish sampled are expanded to account for the time intervals between samples (Figure 10-12), the total estimated numbers of juvenile Chinook collected at the diversion facilities do not seem large compared to the total number of juveniles that may arrive at the Delta. For example, if 50,000 Chinook females spawn an average of 5,000 eggs of which 7% survive to reach the Delta (which does not seem unreasonable given Bradford's (1995) estimate of 7% egg to smolt survival), then the few hundred thousand fish that are normally collected at the diversions would be a few percent of the 17.5 million arriving at the Delta. However, there is also indirect mortality associated with the diversions that is not well understood. Most efforts to study it have involved releases of hatchery fish marked with coded-wire tags, as discussed below.

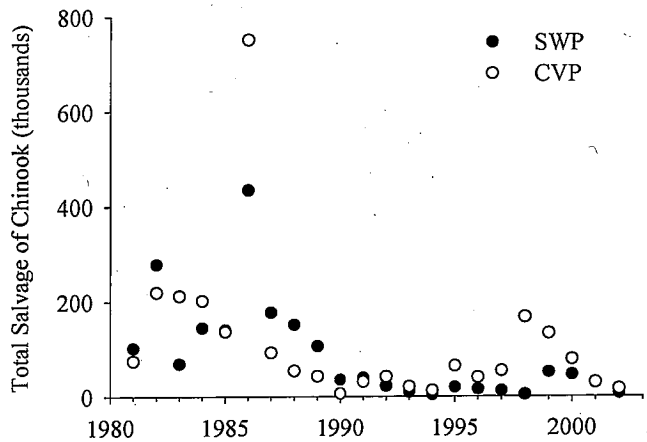



Figure 10-12. Estimated total number of juvenile marked and unmarked Chinook collected at diversion facilities operated by the SWP (solid circles) and CVP (open circles). The high values for 1986 may reflect the very high flows in February of that year. Data from USBR (2003).

**False positive identification of winter-run:**

Concern about direct and indirect losses of fish to Delta diversions varies inversely with the strengths of the populations involved, and is greatest for ESA-listed runs. All hatchery steelhead are now marked, so that identifying naturally spawned steelhead is straightforward. Chinook are assigned to runs by size at date criteria, as described in Ch. 6, and recent genetic analyses have demonstrated the problems with the size approach as applied to winter-run at the state and federal diversion facilities in the Delta (Hedgecock 2002). The initial objective of the genetic work was to use mixed stock analysis to determine the proportion of the salmon taken at the pumps that were winter run, from which the "take" of the listed winter-run might be estimated. This was abandoned, however, when it was realized that the sampling at the pumps did not allow for accurate estimates of allele frequencies in the impacted group of juvenile Chinook, since mixed-stock analysis depends on such estimates. As an alternative, individuals were assigned to runs. Although this did not allow a calculation of take, it did allow a test of the size criteria, with mixed results. Although 95% of the fish that were assigned to the winter-run by genetic analysis were within the winter-run size criteria, only half of the fish with assignable genotypes that met the size criteria were winter-run. In other words, as applied to winter-run at the pumps, the size criteria have a high rate of false positives (Figure 10-13). To complicate matters further, the rate of false positives has varied from 16.3% to 94.6% over the six years in which fish were sampled (1995/6 - 2000/1). This, together with the likely bias in samples selected from salvage, makes it hard to develop a useful estimate of take using the size criteria, and challenges the validity of analyses such as those summarized in Brown and Kimmerer (2001; 2002) that also depend on the size criteria.

When the Hedgecock (2002) work was performed it was possible to identity individuals as winter-run or non-winter-run with high accuracy by genetic analysis, but it was not yet possible to do this for runs that are more closely related, such as fall-run and late-fall run. Nevertheless, a mixed stock analysis by Vanessa Rashbrook of Hedgecock's laboratory showed that the large juveniles in September and October in the fall-run band in Figure 10-13 are indeed fall-run (D.

Hedgecock, pers.comm. April 2003). This result is clear enough that the sampling uncertainties described above do not matter. Additional genetic markers have since been developed, and it is now possible to distinguish individuals of all runs except Feather River spring-run (M. Banks, Oregon State U., pers.comm 2004).

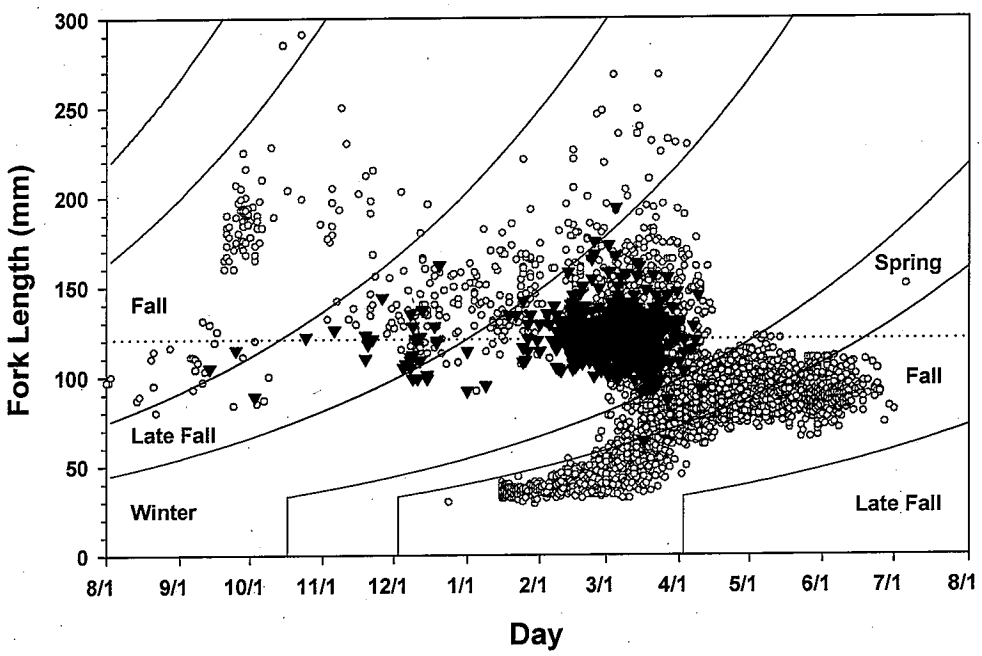



Figure 10-13. Distribution, by fork length and day of capture, of 6,752 juvenile chinook salmon with assignable genotypes over a six-year period, from August 1995 through July 2001. The 711 juveniles assigned to winter-run are shown by dark inverted triangles; fish assigned to other runs are shown by open circles. Note that each symbol may represent more than one fish, and that many non-winter-run are obscured by the tight cluster of winter-run. Mean fork length of winter run juveniles (121 mm) is shown by the dotted line. The figure and most of the caption are copied from Figure 1 in Hedgecock (2002).

## Survival studies

*Fry survival*

Fry survival was studied using coded-wire tags (CWTs) from 1980 through 1987 (Brandes and McLain 2001). Tagged hatchery fry were released in February or March at various locations in the Delta; mean sizes for the groups ranged from 40 to 53 mm fork length, but most were 45-50 mm.[58] Fry released below Red Bluff Diversion Dam were recovered in the ocean fishery at a higher rate than fry released in the Sacramento River near the edge of the Delta, particularly in wet years, despite the greater distance that they had to travel. Based on the data in Brandes and McLain (2001), ocean recoveries of fry released in the Delta are roughly an order of magnitude lower than for smolts released there (Figure 10-14). Whether hatchery fry are reasonable

[58] 0.5 mm "half-tags" were used for these fish, because of their size.

surrogates for naturally produced fry can be questioned, as discussed below. Whatever else happened to the tagged fry, few of them ended up at the pumps; only 46 of about two million were recovered there (Brandes and McLain 2001, App. A).

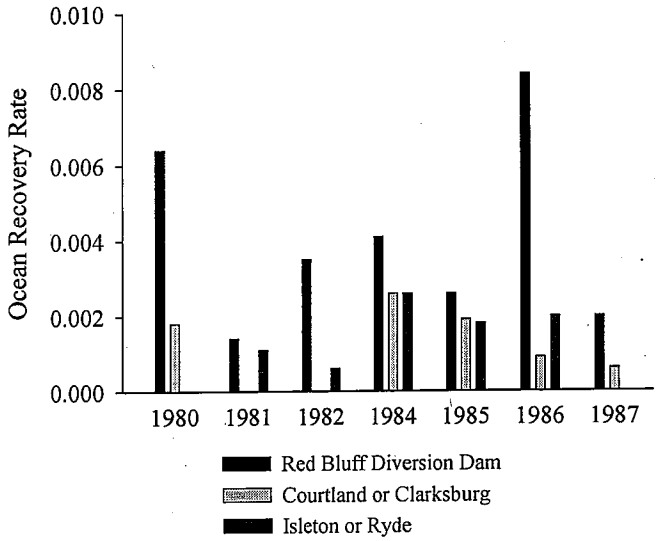



Figure 10-14. Recovery rates in the ocean harvest for ~50 mm chinook fry marked with CWTs and released near Red Bluff Diversion Dam and at locations on the lower Sacramento River. Data from Brandes and McLain (2001).

*Smolt Survival*

Most coded-wire tag studies have involved smolts. Analyses of the data have related survival as estimated by trawl and ocean fishery tag recoveries to covariates such as flow, water temperature, or exports, or whether the Delta cross-channel gates were open, for the relevant period. Early analyses of the CWT data (e.g., Kjelson et al. 1989) used multiple regression to estimate survival as a function of several covariates. This approach was criticized by various parties on a number of technical grounds, for example that linear regression is unsuitable for estimating survival rates that are constrained between 0 and 1, or on the selection of the covariates (Newman and Rice 2002). To move the situation beyond arguments, the California Urban Water Agencies and the U.S. Fish and Wildlife Service funded two independent statisticians, John Rice of the University of California Berkeley and Ken Newman of the University of Idaho, to apply more advanced methods to the data. A group of biologists and engineers representing various parties provided assistance in selecting and compiling covariates for 101 releases groups from 1979 to 1995 that were used in the analysis.[59]

The Newman-Rice study was essentially completed by 1998, although it was not published in the professional literature until 2002,[60] and to a considerable extent the preliminary reports defused the controversy. On the one hand, they generally supported the findings of the earlier

[59] Some of these covariates are complex and opaque; for example, the tide covariate is described as "a measure of the magnitude of the change in low-low and high-low tides and whether the delta was filling or draining." As far as I know no detailed description of the development of these covariates is available, which is unfortunate.
[60] The article was submitted in October 1998; apparently a very long lag time for publication is not unusual in statistics.

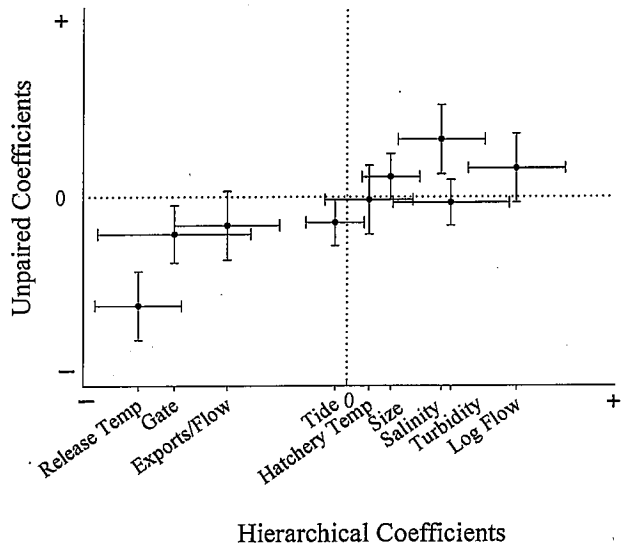
studies, but they also highlighted the limitations of the data and the need to apply the results cautiously. The technical level of the modeling is also beyond the ken of all but a few of the scientists involved with Central Valley salmon, which may have discouraged controversy. Newman continued with additional analyses, but this IEP-funded work has been largely free of the political tension that marked the early phases of the work with Rice. More recently, CUWA has sponsored another statistician, Bryan Manly, to participate in analyses of the cwt data.

One important difference between the Newman and Newman-Rice studies is that Newman and Rice (2002) estimated the effect of various environmental factors on recaptures of a larger number of groups of CWT fish that were released upstream and recovered at Chipps Island and in the ocean fishery. Newman (2003) focused on a subset of these groups for which groups released farther upstream could be paired with groups released just downstream from Chipps Island. Thus, Newman and Rice (2002) estimated the probability of survival times the probability that surviving fish are captured. By assuming equal probability of marine survival and capture for the paired releases, Newman (2003) estimated only probability of survival. Newman and Rice (2002) also used export/inflow ratio as a covariate, while Newman (2003) used exports.

The Newman and Rice analyses are described in more detail in Appendix B, but the main results can be summarized by a comparison of the original Newman and Rice (2002) study and the hierarchical model by Newman (2003). To facilitate comparison with the unpaired model of Newman and Rice (2002), Newman (2003) also reported results from the paired models using the export/inflow ratio rather than exports as a covariate (Figure 10-15); there are strong similarities but some important differences between the paired and unpaired analyses.

By the criterion that strong effects have coefficients more than two standard errors from zero, the temperature of the water into which fish were released (release temperature), whether the Delta Cross Channel gate was closed (gate position), and the export/inflow ratio had strong negative associations with survival for the hierarchical model, and fish size, salinity, turbidity, and the log of flow in the Sacramento River had strong positive associations. Of these, the export/inflow (E/I) ratio, fish size, turbidity, and log flow were not "strong" in the unpaired analysis (although fish size was very close), and only tide was a "strong" effect in the unpaired analysis but not in the hierarchical analysis. The greatest contrast concerns turbidity, which had little effect on predictions of the unpaired model. Newman (2003) speculated that this may result from turbidity increasing survival but also increasing the probability of capture in the trawl, and so having little effect in the unpaired model which estimates probability of survival times probability of capture, rather than probability of survival. Another important difference concerns Sacramento River flow, which has a much stronger association with survival than the hierarchical model.

Figure 10-15. Comparison of estimated coefficients plus/minus two standard errors for the unpaired analysis of Newman and Rice (2002) and the hierarchical analysis of Newman (2003) with release-specific capture probabilities.




Release temperature has been strongly associated with survival in all analyses. An early application of modern statistics to the Central Valley coded-wire tag data, by Baker et al. (1995), focused on the effect of temperature, and estimated a 95% confidence interval for the temperature at which mortality of tagged fish reaches 50% as 23.01 ±1.08°C (73.4 ± 1.94°F).

Newman and Rice (2002) provided an example of the use of the unpaired model to compare the relative survival that might be expected from two options of management of the river that affects the covariates in the model, in this case the export/inflow ratio and the position of the cross-channel gate. They note, however, in a comment that also seems relevant to the paired-release models, that (p. 990):

> Comparisons such as this must be tempered with caution, however. Our model summarizes historical relationships and is relevant to prediction in such a passively observed system. But because a number of unmeasured variables may well be important, it is much less well suited to predicting what would happen if the system were directly manipulated (Box 1966). Thus it would be a mistake to take literally the numerical predictions of the model in the latter case; a more modest and realistic hope is that they point to beneficial management strategies.

Moreover, the models embody assumptions, such as the assumption of equal catchability in the unpaired model and of equal (or constant ratio) survival downstream from Chipps Island for the paired models, that are at best approximately valid. More fundamentally, the data are for hatchery fish, which may not be a reasonable surrogate for naturally produced fish, as discussed below.

It seems likely that Newman and Rice have wrung as much information regarding smolt survival in the Sacramento River and Delta from the historical CWT data as can be got by purely statistical analyses, and that focused studies such as the Delta Cross-Channel studies that can clarify the actual processes underlying the statistical associations are the next logical step. For example, flow and salinity are inversely related, so it seems curious that both should be positively related to survival. The data used for the statistical studies show that salinity was uniformly low when flow in the Sacramento River was above about 20,000 cfs, high when flow was less than about 7,500 cfs, and highly variable in-between (Figure 10-16). There is a group of about 11 data points with low flow (<10,000 cfs) and low salinity, which presumably had poor survival, and it seems worthwhile to investigate the particular circumstances at those times. Eight of these are from April or early May 1994. Investigating the circumstances in which salinity and discharge were both low might suggest testable hypotheses for the association identified by the statistical studies.

The CWT data also include information about ocean conditions, however, in the coefficients for the indicator variables for release year. The effects of ocean conditions on survival will be confounded by year-to-year variation in fishing effort and the variable ages of fish recovered in the ocean (2, 3 or 4 years), but these might be sorted out by state-space modeling (K. Newman, U. of St. Andrews, pers.comm, March 2003). Such an analysis might be most useful as a means to test hypotheses developed from other information about which ocean conditions are favorable or unfavorable for Central Valley Chinook.

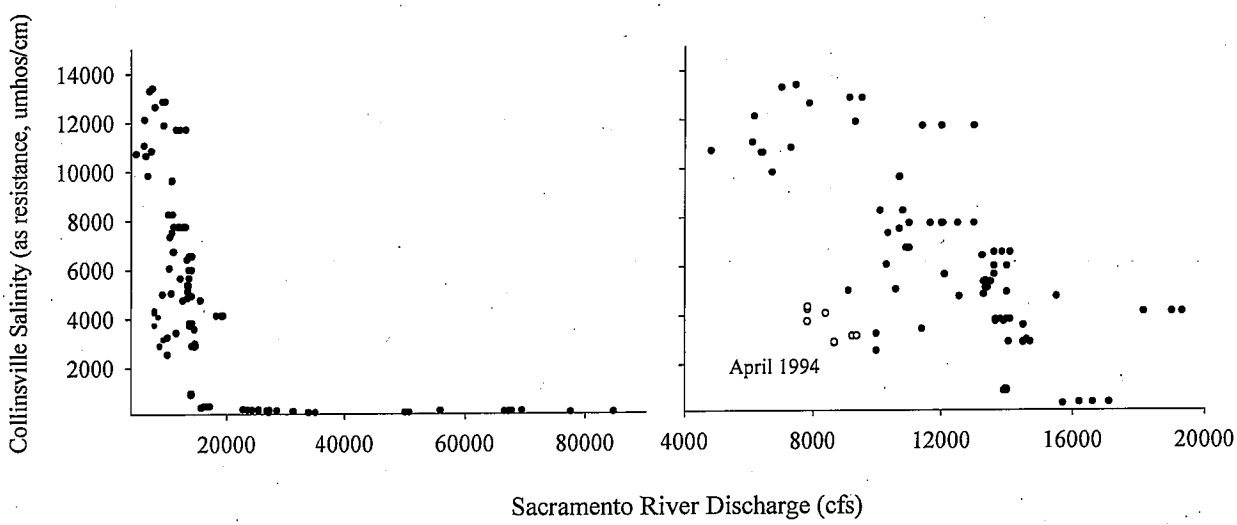



Figure 10-16. Values of salinity and Sacramento River Discharge used to characterize these conditions in the Newman and Rice (2002) analysis. A. all data; B. data for Q < 20,000 cfs, with eight data points (one is obscured) from April 1994 shown as open circles. Data from Alison Britton.

The paired analyses described above assume that the survival of fish released just downstream from Chipps Island is the same as the survival of the fish released at Sacramento or Courtland that pass Chipps Island. Newman (2003) describes several reasons to doubt this, and

the most biologically plausible reasons suggest that fish released downstream from Chipps Island should not survive as well. It seems likely that the hatchery fish used for the studies are not all equally likely to survive, but that there is a distribution of "survivability," so that fish with low survivability would already have been culled from the group released upstream by the time it reached Chipps Island. There is also good evidence that downstream migration is a self-reinforcing process (Høgåsen 1998; Ewing et al. 2001), so fish released upstream will be farther advanced in the smolting process and will be migrating more rapidly when they pass Chipps Island than will the group of fish released downstream from Chipps Island. There may also be an initial period of higher mortality following release, as fish adapt to life in the wild. Whatever the cause, the "shock effect" can be modeled by assuming that the mortality rate of the downstream group is some fixed multiple of the mortality rate of the upstream group. Newman (2003) found that doing this had relatively little effect on the estimated coefficients, although it decreased the estimates of survival and increased the estimates of the probability of capture. Estimates of the multiple or the shock effect were substantial, however, particularly for the hierarchical model.

There is independent evidence for a shock effect. For three experimental releases, hatchery Chinook trucked to the bays but allowed to acclimate in off-shore net pens before release survived ~2.5 times better than control fish released directly into the bays (Brown et al. 2004). Hatchery fish show a growth check in their scales or otoliths at the time of release (Rich 1920; Zhang et al. 1995). Newman (2003) noted that if shock also occurs with the upstream releases, which seems likely, then survival indices estimated from these releases would underestimate the survival of naturally-produced fish or of hatchery fish that are already acclimated to the river.

Coded-wire tags have also been used to estimate mortality in the Clifton Court Forebay to the SWP diversion facilities in the Delta, as described by Gringas (1997). Tagged salmon and striped bass have been released at the radial gates that separate the forebay from Old River and at the trash rack just upstream from the salvage facility, and recovered in the facility. Fish not recovered were assumed to have died. Estimated mortality for salmon in the forebay has ranged from 63 to 99%, with no obvious patterns in the data (Figure 10-17). The estimated forebay mortality is large and plays an important role in the calculation of the take of winter-run Chinook, so it seems that more effort should be made to characterize it well, as urged by the 2002 EWA Review Panel (2002). The estimates should also be reconciled with the observation by Kimmerer (2004) that similar numbers of fish are salvaged at the state and federal facilitates, although the federal facilities do not have a forebay. A strong shock effect, from high initial rates of predation on naïve hatchery fish, might help to explain this observation. This could be tested by checking whether water temperature affects the ratio between fish salvaged per volume of water exported at the two facilities, since the rate of predation should increase with water temperature. Such a shock effect could also explain the seemingly low survival rates (~15-20%) for juvenile Chinook in the lower San Joaquin River estimated by the VAMP experiments.

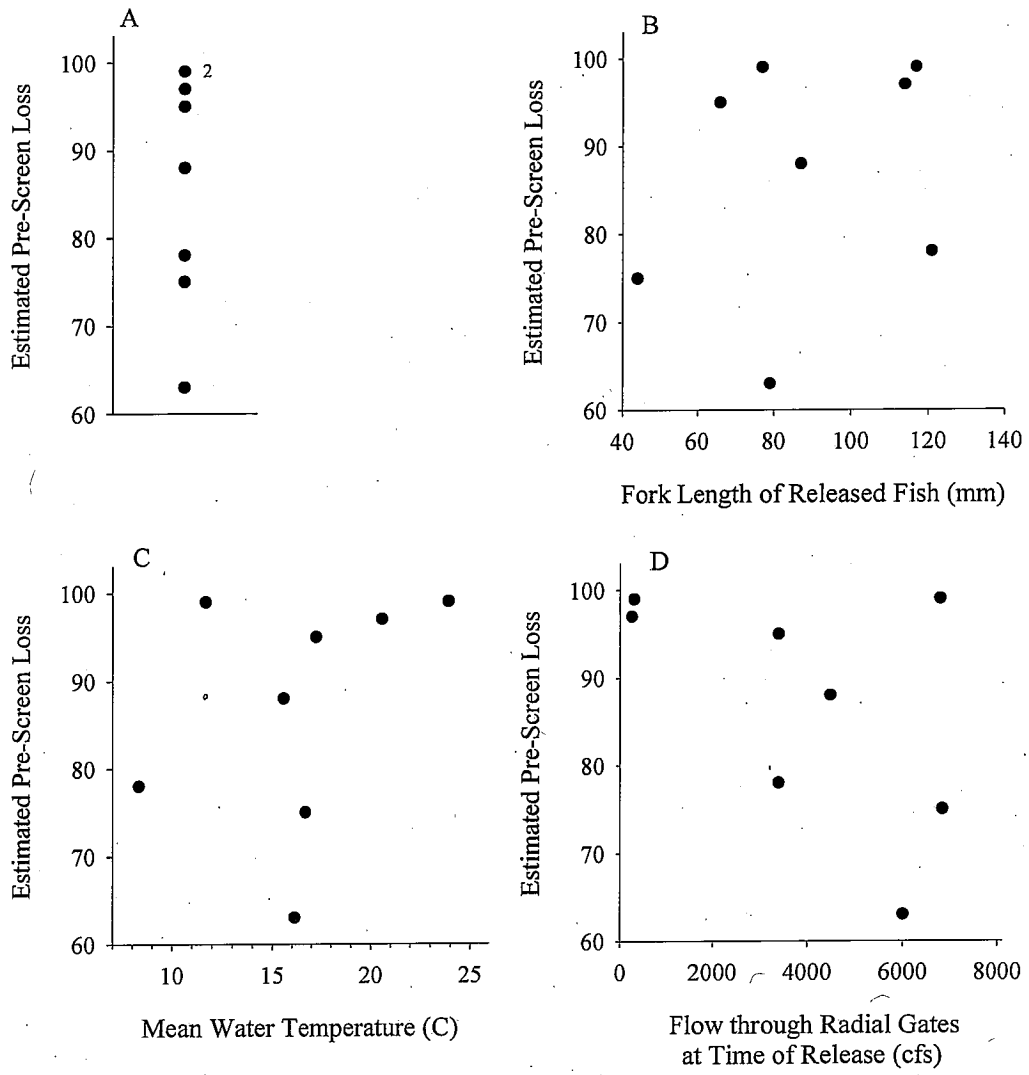



Figure 10-17. Estimated mortality of coded-wire tagged juvenile salmon in Clifton Court Forebay: A, overall distribution; B, as a function of, fork length; C, of water temperature, and D of flow through the radial gates; one point in A represents two estimates. Data from Table 1 in Gringas (1997).

In summary, the main result of the CWT studies seems to be that several factors influence the survival through the Delta of tagged hatchery fish, and of these, only water temperature stands out.

*Are hatchery fish reasonable surrogates for naturally produced fish?*

The utility of the CWT studies depends on the assumption that hatchery fish are reasonable surrogates for naturally produced fish. Although some studies have addressed questions specific to hatchery fish, such as the relative survival of fish released upstream or downstream of the Delta, most of the interest lies with naturally produced fish. There is good evidence for differences between hatchery and naturally produced fish, but it can be argued that the differences in the survival of hatchery fish with water temperature and other environmental variables also apply to naturally-produced fish, even though the absolute survival rates may

differ. This matter was recently argued in an expert review of proposed methods for measuring smolt survival in the Tuolumne River (CWWR 1999), one of which involved CWTs. On the one hand, Anne Kapuscinski (University of Minnesota) asserted in her comments that:

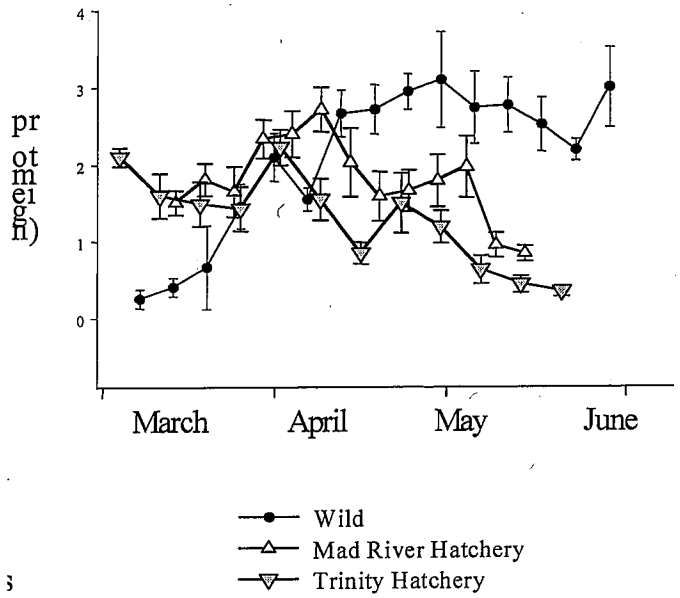
> There are numerous behavioral and physiological differences between hatchery-propagated and wild-born fish, differences likely to affect downstream survival. These differences arise, in part, because hatchery fish develop physiologically and learn their behaviors under fundamentally different and often more homogenous environmental conditions than wild fish. If smolt survival assessments rely on hatchery fish, the effects of hatchery rearing on outmigration survival will be confounded with the effects of flow rates or habitat restoration. ... Because we don't understand the complex interactions among environmental and biological factors affecting seaward migration survival, monitoring of hatchery fish could even be misleading about the suite of in-river conditions needed to achieve an increase in naturally reproducing chinook salmon ..."

David Hankin (Humboldt State University) stated the alternative view, that useful inferences can be drawn from studies of hatchery fish.

> I find myself less concerned about use of hatchery-reared fish for survival studies than were some of the other peer reviewers. To me, the hatchery fish provide a nice "standardized" and available source of fish. If experiments using hatchery fish show that survival rates of these fish are very poor in the mining reach (as compared to the upper Tuolumne reach), then I am willing to conclude that survival rates of wild fish are probably also lower in the mining reach than in the upper Tuolumne. I would not be willing, however, to conclude that the absolute survival rates of wild and hatchery fish would be the same in the two areas. But I don't think knowledge of the actual survival rates is necessary to provide guidance for restoration or even evidence of improvements in survival rates after restoration activities.

As an example of the kind of difference that concerns Kapuscinski (although she did not cite it), Kerstetter and Keeler (1976) showed that the surge of activity of gill Na+K+ ATPase, an enzyme associated with smolting, occurred a month or more earlier in two strains of hatchery steelhead in the Trinity River than it did in wild fish, and there were also differences between the two hatchery strains (Figure 10-18). Since increased gill ATPAse activity is associated with migratory behavior (Zaugg and Wagner 1973, Ewing et al. 2001), and gill Na+K+ ATPase activity tends to cycle in hatchery chinook but not in wild Chinook (Ewing et al. 2001), it is easy to imagine that the relative survival of hatchery and wild fish could change over the season. However, definitive evidence on this point is lacking.

Figure 10-18. Difference in ATPase activity among wild and hatchery steelhead. Gill $Na^+K^+$ ATPase activity in wild Trinity River steelhead and two hatchery strains. Bars show standard errors; data from Kerstetter and Keeler (1976).




A related difficulty concerns populations of juvenile chinook in which some appear to be migrating actively (and have higher levels of gill Na+K+ ATPase activity) while others seem to migrating more passively and slowly. This is the situation with spring Chinook in the Rogue River which migrate in their first summer, reaching the estuary in September or October (Ewing et al. 2001). Fish captured in traps in the center of the channel were mainly from the more rapidly migrating part of the population, while those captured in beach seines were mainly not (fish were marked and recaptured at various places along the river so differences in migration rates could be determined). It would seem difficult for a homogenous group of hatchery fish to represent even the relative survival of both segments of the wild population.

**Use of the bays by juvenile Chinook**

Too little is known about the use of the bays by juvenile Chinook. MacFarlane and Norton (2002) reported one year of a ten-year field study of juvenile fall and perhaps spring-run in the bays (reviewed in Ch. 6), and analyses of the data from subsequent years is now underway (B. MacFarlane, NMFS, pers.comm. 2005), so much new information should be available soon. However, the sampling for these studies began in April, and collected fish with a trawl in relatively deep water. All that is known about fry migrants in the bays is that they are taken in small numbers in the IEP seine sampling, mainly in wet years.

**Diet**

Information is available on the diet of juvenile Chinook in other estuaries (Healey 1991; Bottom et al. 2005) as well as in the San Francisco Estuary (Rutter 1904; Scofield 1913; Ganssle 1966; Sasaki 1966; Heubach 1968; Fields 1976; Kjelson et al. 1982; MacFarlane and Norton 2002). Healey (1991:346) noted that "Diets vary considerably from estuary to estuary and from

place to place within an estuary," and also that seasonal changes in diet are typical. The available information for the San Francisco Estuary seems consistent with these observations. From an analysis the stomach contents of 540 juvenile Chinook (< 70 mm) from the Delta and 189 from the bays, Kjelson et al. (1982:402) reported that:

> Crustáceans and insects dominated Chinook [< 70 mm] stomach contents, with an increase in crustacean ingestion downstream ... Cladocera and diptera were consumed frequently in the Delta, while in brackish San Pablo and San Francisco Bays, consumption of copepods, amphipods, and fish larvae increased. Similar food habits were reported for older fry and smolts in [earlier] Delta studies ...

MacFarlane and Norton (2002) examined the stomachs of 93 juvenile Chinook collected between Chipps Island and the Gulf of the Farallones from April 30 to July 15, 1997, and reported that fish leaving the Delta contained mainly amphipods, other crustaceans, and insects. In Suisun Bay insects, especially waterboatmen, and crustaceans were the main food items, along with some fish larvae. Crustaceans were the dominant food in San Pablo Bay, and fish larvae were dominant in Central San Francisco Bay.

Given that juvenile Chinook are opportunistic feeders in estuaries (Healey 1991), the more relevant question may not be what juvenile Chinook in the San Francisco Estuary eat, but what quality it is and whether they get enough of it. This seems questionable. MacFarlane and Norton (2002) found that juvenile Chinook moving through the bays grew slowly (0.18 mm d-1 on average) until they reached the Gulf of the Farallones. Kjelson et al. (1982) noted that the scales of fish from the Sacramento-San Joaquin system did not show the pattern of intermediate circuli spacing indicative of enhanced growth in brackish water, as reported by Rich (1920), Snyder (1931) and Reimers (1971; 1973) for the Columbia, Klamath, or Sixes rivers. MacFarlane and Norton (2002:225) concluded that "... juvenile Chinook salmon derive little benefit from their time in the [brackish water part of the] San Francisco Estuary." In contrast, Magnusson and Hilborn (2003) reported from a comparative study of rivers from northern California through Washington, the survival of tagged hatchery fall Chinook increased with the proportion of the estuary that was in natural condition.

Poor growth in the bays of the San Francisco Estuary may reflect changed conditions in the estuary, as noted by MacFarlane and Norton (2002). Scofield (1913:17), in a report of towing a live car filled with Chinook and steelhead fry from Sacramento to the Golden Gate, reported that there was "a plentiful supply of land insects" on the surface of Suisun and San Pablo bays in May, 1912, so that Chinook fry could continue "their habit of surface feeding until well out in salt water." Scofield also reported abundant "small crustaceans, especially young shrimp" at the surface of Suisun and San Pablo bays. He caught "quantities" of these with a gauze tow net, and the fry "devoured them greedily." Unfortunately, old collections of scales apparently have been lost, so the speculation that the estuary formerly offered better conditions for growth cannot be tested.

Although published data form the NMFS study on fish passing through the bays are available only for 1997, data on juveniles passing into the ocean are now available for 1998 and 1999. There is year to year variation in the size and condition of juvenile Chinook leaving the bay (Table 10-1), as might be expected from similar variation elsewhere in the rivers and the Delta. Fish at the Golden Gate were smaller and older in 1997 than in the other two years. The strongest variation is in energy stored as triacylglycerol, normalized to cholesterol (TAG/CHOL). Although growth of juvenile Chinook in the bay has been consistently low and condition (Fulton's K) has consistently declined in fish passing through the bay, TAG/CHOL has been variable from year to year (B. MacFarlane, NMFS, pers.comm. 2006). Why this should be so is not clear.

Table 10-1. Measures of condition of juvenile fall or Chinook captured near the Golden Gate. Data from MacFarlane and Norton (2002) and MacFarlane, et al. (2005).

| Year | Length (mm) | Weight g | Age d | TAG/CHOL | Fulton's K |
|---|---|---|---|---|---|
| 1997 | **85.5±1.1 (64)** | **7.23±.3 (64)** | **176±3 (32)** | **9.5**[1] | **na** |
| 1998 | **87.6±0.5 (255)** | **7.1±0.1 (255)** | **160±1 (106)** | **4.1±0.4** | **1.04±??** |
| 1999 | **92.0±1.0 (124)** | **8.6±0.3 (124)** | **168±3 (60)** | **15.37±1.56** | **1.05±??** |

# CHAPTER SIXTEEN

# HYDROSYSTEM MANAGEMENT

*At the present time, no salmon enter these streams [Feather, Yuba, American, Mokelumne, Tuolumne rivers]. It would be safe to estimate that one-half the streams in this State to which salmon formerly resorted for spawning have, for this purpose, been destroyed by mining. As mining is the more important industry, of course, for this evil there is no remedy, other than by artificial means to increase the supply in those tributaries that are still the resort of these fish.*

Report of the Commissioners of Fisheries for 1876 and 1877

*Although the plans to build a huge dam on the Sacramento River had been in print for at least seven years (citation), it was not until complete specifications for the Shasta Dam were published and the bids received for consideration that a study of the probable effects of this dam on the fishery resources of the river system was begun.*

Hanson et al. (1940:1)

*Development of the California Water Plan [i.e., the SWP] will create considerable environmental changes in the Sacramento-San Joaquin Delta. Major changes will occur in the amount and pattern of water flow, water quality and salinity incursion. A knowledge of the major factors affecting fish distribution and abundance is essential if we are to protect and enhance, if possible, the fishery resources of the Delta ...*

J. L. Turner (1966:9)

*There is a growing public recognition that one of the most important public uses of tidelands – a use encompassed within the tidelands trust – is the preservation of those lands in their natural state, so that they may serve as units for scientific study, as open space, and as environments which produce food and habitat for birds and marine life, and which favorably affect the scenery and climate of the area.*

Marks v. Whitney (1971) 6 Cal.3d 251

*The prosperity and habitability of much of this state requires the diversion of great quantities of water from its streams for purposes unconnected to any navigation, commerce, fishing, recreation, or ecological use relating to the source stream. The state must have the power to grant unvested usufructuary rights to appropriate water even if diversions harm public trust uses. Approval of such diversion without considering public trust values, however, may result in needless destruction of those values. Accordingly, we believe that before the courts and agencies approve water diversions they should consider the effect of such diversions upon interests protected by the public trust, and attempt, so far as feasible, to avoid or minimize any harm to those interests.*

National Audubon v. Superior Court (1983) 33 Cal.3d 419

This chapter gives a brief review of water management in the Central Valley as it affects salmon, and is intended mainly as background for readers who are unfamiliar with the area. More detailed descriptions can be found in various documents, such as NOAA Fisheries (2004),

and the 2005 California Water Plan (http://www.waterplan.water.ca.gov). Management of harvest is discussed briefly in Chapter 14; legal issues related to instream flows, particularly regarding the Public Trust Doctrine as applied to water in California, are described in Appendix C.

All major Central Valley rivers are blocked by large dams with substantial reservoirs, as well as by various smaller dams (Ch. 3). Water stored in major reservoirs in the Sacramento Valley is mostly released into the rivers for diversion farther downstream, particularly in the Delta, so on annual average, flows in the rivers below the dams are not much reduced from natural levels. Shasta Dam on the Sacramento River and Folsom Dam on the American are part of the Central Valley Project (CVP), while Oroville Dam is part of the State Water Project (SWP). New Bullards Bar Dam on the North Fork Yuba River is owned by a local agency, and unlike the others, supplies mainly local demand. In the San Joaquin Valley, stored water is applied mainly to local uses, and major canals divert directly from the reservoirs, so that average flows in the downstream reaches available to salmon are much reduced from their natural level. In the extreme case of Friant Dam on the San Joaquin River, not enough water is released to satisfy downstream water rights, water from the Sacramento system is pumped south in the Delta-Mendota Canal to satisfy those water rights, and not enough water remains in parts of the river to allow fish migration. Friant Dam and Goodwin Dam on the Stanislaus River are part of the CVP, while New Don Pedro Dam on the Tuolumne River and New Exchequer Dam on the Merced River are owned by local agencies, as is Pardee Dam on the Mokelumne River, which drains directly to the Delta. This patchwork of ownership does not facilitate coordinated management.

For historical reasons including the importance of the mining industry, California recognizes both riparian and appropriative water rights (Littleworth and Garner 1995). The Mediterranean climate of the state, with an annual summer drought, makes extensive irrigation necessary, and large areas of the Central Valley were subject to frequent winter and spring flooding before the development of levees, flood bypasses, and multi-purpose dams. These and other developments had disastrous effects on Central Valley salmon (Ch. 3). Over time, however, more attention has been given to protection of fish and the environment. Fish protection was essentially an afterthought in the design of the CVP (Hanson et al. 1940), but major studies of the Delta were conducted during the design of the SWP (e.g., Fish Bulletins 133 and 136). This trend continued as the environmental movement developed as a political force, laws such as the Endangered Species Act and National Environmental Policy Act and their California counterparts were enacted, and the public trust doctrine was extended by the California Supreme Court to provide environmental protection to tidelands and to navigable waters or their tributaries in *Marks v. Whitney* (6 Cal.3d 251) in 1971 and *National Audubon Society v. Superior Court* (33 Cal.3d 419) in 1983. Thus, water management in the Central Valley is based on a complex web of rights and regulations that has evolved over time to accommodate new projects and changing legal and political environments.

The 1987-1992 drought created great tension between instream and consumptive needs for water, particularly because of the recent listing of winter Chinook under the Endangered Species Act. Political gridlock ensued, but was eased by the 1994 Delta Accord, which provided for interim protection for listed species, along with certain principles for managing the Delta and water diversions in the short term. The Delta Accord was implemented largely through Decision 1641 by the State Water Resources Control Board (SWRCB), in 1995.

The SWRCB deals with water quality as well as water rights, and because water quality in the Delta depends on inflows, water quality standards are in effect flow standards. In the abstract, the SWRCB has great authority in California water issues, but in practice has played a cautious and limited role in the Central Valley in recent decades. Instead, the lead role was taken by CALFED, a consortium of state and federal agencies which was transformed by the Delta Accord into a multi-agency effort to develop a comprehensive resolution to Central Valley water issues. This effort now has independent institutional existence as the California Bay-Delta Authority. CALFED has programs dealing with such matters as new water storage facilities, levee stability, and water transfers, but also with ecosystem restoration and science. Notably, the ecosystem restoration program emphasizes the importance of geomorphic processes in the creation and maintenance of habitats. Generally, money for restoration programs has been distributed through a process of competitive proposals. However, the organizational structure of CALFED has been sharply criticized (CLHC 2005), and CALFED is now going through a period of "re-focusing" and "re-invigoration" (CALFED 2005).

The Environmental Water Account (EWA) is a major CALFED program that is designed to reduce conflicts between exports from the Delta pumps and protection of ESA-listed fish. Water is acquired and moved south of the Delta when the diversions are thought to be less harmful, or is acquired south of the Delta, and banked. The banked water is used to replace water that is not pumped at times that are thought to be more harmful (CALFED 2005). Water is acquired in several ways, but mainly by purchasing water from willing sellers, by temporarily relaxing normal restrictions on Delta pumping, or by using water allocated to environmental uses under other programs. In another aspect of the program, hydropower producers can be compensated for foregone power generation, for example when cool water is released from outlets below the hydropower intakes, in order to reduce temperatures in the river downstream. Although the EWA has been successful in reducing conflicts, it is less clear that it has benefited listed Chinook or steelhead (NOAA Fisheries 2004).

The Central Valley Project Improvement Act (CVPIA), enacted in 1992, made fundamental changes in the CVP authorization, giving protection and restoration of fish and wildlife and associated habitats equal priority to municipal and irrigation uses of water, and enhancement equal priority with hydropower production. In particular, section 3406(b) called for implementation of a program "which makes all reasonable efforts to ensure that, by the year 2002, natural production of anadromous fish in Central Valley rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-1991." It also specified a number of measures intended to effect the new fish

and wildlife purposes, including dedication of 986.7 million $m^3$ [800,000 acre feet] of "CVP yield" to fish and wildlife purposes, and setting up a restoration fund to provide up to $50 million annually for fish and wildlife restoration. Section 3406(g) calls for development of "readily usable and broadly available models and supporting data to evaluate the ecologic and hydrologic effects of existing and alternative operations of public and private water facilitates and systems in the Sacramento, San Joaquin, and Trinity River watershed." These should provide improved scientific understanding of, among other things, "measures needed to restore anadromous fisheries ....", and "development and use of base flows and channel maintenance flows to protect and restore natural channel and riparian habitat values." The Secretary of the Interior was also charged with determining instream flow needs for all CVP controlled streams (3406(b)(1)(B)), based on recommendations of the USFWS after consultation with the CDFG.

Although some progress has been made, the CVPIA has made less difference than its proponents expected (McCarthy 1997). For one thing, litigation resulted in most of the 800,000 acre feet of CVP yield effectively being assigned to maintaining the status quo in the American River.[88] More fundamentally, implementation of the CVPIA revealed the limitations of current scientific knowledge and understanding, and the resulting difficulty in developing effective restoration programs. As a simple example, the estimate of natural production of Chinook salmon during the 1967-1991 base period is little more than an educated guess; estimates of harvest and estimates of varying quality of adult returns existed for most streams, but these were simply divided by two to estimate natural production (Mills and Fisher 1994).

All major Central Valley dams except Friant release water to provide habitat for fish below the dams, and as a result of current litigation, water presumably will soon be released from Friant, as well (Appendix C). Instream flow requirements are determined by the Federal Energy Regulatory Commission (FERC) for non-CVP projects with hydropower licenses,[89] and for other dams by the SWRCB, or alternatively, by a court, since the California courts also have jurisdiction over instream flow questions. From time to time instream flow requirements are reconsidered, for example when FERC licenses expire, and in most cases, instream flow requirements have been increased when permits were reviewed. For example, the license for Oroville Dam is currently under active review. For Shasta, a standard originally intended to protect navigation, 99 to 142 $m^3s^{-1}$ (3,000 – 5,000cfs) depending on storage in Shasta, now effectively operates as a fish protection standard. Important legal developments affecting

[88] *San Luis and Delta Mendota Water Authority v. US* (U.S. District Court, E.D. Cal, CV-F-97-06140-OWW). As of 1992, the legally binding instream flow standards in the American River were set in the permit for Folsom Dam. These called for flows of 250 or 500 cfs (7.1 or 14.2 $m^3s^{-1}$), depending on the time of year. Subsequently, the SWRCB set higher standards, in a 1972 decision permitting the proposed Auburn Dam. These called for 1,500 cfs (42.5 $m^3s^{-1}$) unless CVP contractors were rationed, in which case somewhat lower flows applied. Since Auburn Dam was not built, the higher standards did not go into legal effect, although the Bureau of Reclamation operated Folsom as if they were. The CVPIA provided that the 800,000 acre-feet would go, among other things, to meet new legal obligations placed on the CVP following its enactment; thus, most of it has gone into the difference between the two sets of standards on the American River. Presumably, this was not the result intended by proponents of the CVPIA.

[89] Federal authority regulating hydropower production normally preempts state authority regarding instream flows (*California v. FERC*, 1990), but the Reclamation Act that provided authority for building the CVP explicitly required that state law be observed.

instream flows in the last few decades have mostly come from court decisions. In essence, these require that instream and consumptive uses of water be balanced, with considerable weight given to instream uses, and allow the balancing to be reconsidered in light of new information (Appendix C). To do such balancing in a straightforward way would require better information about the effects of water management on stream ecosystems than is generally available, which makes an adaptive (i.e., experimental) approach appropriate (Castleberry et al. 1996).

The major Central Valley reservoirs serve for both flood control and water storage. The reservoirs are drawn down in late fall to provide temporary storage for regulating runoff from winter storms, and then allowed to refill, mainly from snowmelt runoff, as the risk of major storms declines in the spring. During the winter, releases from the dams are increased during and after the storms, and then "ramped down" as the reservoir level drops back toward to the appropriate level. Maximum controlled releases are set at levels intended to prevent or at least minimize flood damage. Controls on the rate of change of the releases (ramping rates) to avoid stranding fish, or on decreases in flow after fish have spawned to avoid stranding redds, are other aspects of instream flow management. Generally these controls are specified in agreements, or are negotiated on a case by case basis by project operators and biologists for regulatory agencies, since the best course of action can depend strongly on the particular circumstances. Although there is no doubt that stranding does kill juvenile salmon, the importance of stranding mortality as a control of populations remains unclear (Ch. 8). Probably the stranding of fall-run redds below Keswick Dam is the most serious example.

During the summer a temperature gradient develops in reservoirs of much depth, with cooler and denser water lying below warmer water, so the temperature of releases from dams can be managed by adjusting the depth at which water is withdrawn and the amount of water discharged. Temperature management is simpler with reservoirs such as New Melones that are large relative to the annual flow in the river. Dams such as Shasta and Folsom were built without facilities for regulating the depth of withdrawals effectively, but these have been added recently, at considerable expense.

When cool water is released into a river during warm weather, its temperature rises toward an equilibrium temperature for the immediate environment at a rate that increases with the difference between the actual and equilibrium temperatures, and decreases with the mass of water involved (Deas and Lowney 2000). Thus, the temperature in the river at a given point downstream from the dam depends on the discharge, which affects both the amount of water to be warmed and the duration of the warming, since the velocity of the flow increases with discharge. Conversely, during cool weather in the fall-run spawning season, the rate of cooling may also decrease with discharge. Management of water temperature and management of instream flows are therefore linked, and temperature standards may act as flow standards.

Releasing cool water from dams can maintain habitat for salmonids for considerable distances. Even in the hot summer in the northern Central Valley, releases of cool water from Shasta Dam normally keep the Sacramento River cool enough for eggs of winter-run

Chinook to survive (<~14°C) for over 50 km (Deas et al. 1997). For the Sacramento River in the summer, the river usually approaches equilibrium temperature near the city of Sacramento. Managing water temperature is particularly challenging on the American River, where authorities try to maintain summer habitat for steelhead using a limited pool of cool water in Folsom Reservoir, and also to retain some cool water in reserve to accelerate cooling in the fall for spawning by fall-run Chinook. Management of water temperature on the Feather River is directed toward rice cultivation rather than fish; most of the water released from Oroville Dam passes through the shallow Thermalito Afterbay, where it warms enough that water diverted to irrigate rice will promote good growth, and cool water habitat in the river is restricted to the 13 km of channel upstream from the Thermalito Afterbay Outlet.

Since 1995, flows in the Delta have been managed largely in terms of an outflow-related salinity index called "$X_2$," as specified in Decision 1641 of the State Water Resources Control Board (SWRCB). $X_2$ is an ecologically-based index that is roughly the distance in kilometers up the axis of the Estuary from the Golden Gate to where the tidally-averaged, near-bottom salinity is 2 practical salinity units (psu) (Kimmerer 2004), and is determined by recent and current outflow from Delta.[90] The management requirements for "$X_2$ days" vary according to the flow in specified Central Valley rivers, with $X_2$ held farther down-Estuary in wetter years and vice versa. Besides $X_2$, SWRCB Decision 1641 imposes constraints or standards for diversions at the CVP and SWP pumps, specified in terms of an Export/Inflow (E/I) ratio and total export rates, minimum Delta outflow requirements, flow requirements in the lower San Joaquin and Sacramento rivers, and municipal and industrial (M&I) water quality standards at specific points in the Delta. Restrictions on the take of listed salmon and steelhead may also constrain pumping.

Three basic "knobs" are available for managing Delta water quality. First is regulating the rate of pumping itself; shifting diversions from one pump to the other allows for minor adjustments. Second is managing the routes of flow into the Delta, either by opening or closing the Delta Cross Channel, an artificial distributary that connects the Sacramento River with the interior Delta, or by closing the head of Old River, a distributary of the San Joaquin through which water flows to the pumps. Closing these channels causes water and associated fish to flow farther downstream in the mainstem rivers before moving toward the pumps, but closing the Delta Cross Channel causes more saline water to be entrained into the flow to the pumps, and blocking the head of Old River may cause more Delta smelt, another ESA listed species, to be so entrained. The third approach is to adjust Delta inflows, mainly by releases from CVP and SWP reservoirs. Thus, management of the Delta directly affects conditions in the rivers, and vice versa.

SWRCB Decision 1641 also established a major program to test the rationale for a controversial proposed standard for Delta inflow in the San Joaquin River to protect Chinook smolts. Although the data were clear that smolt survival was higher in wet years when spring discharge is high, a relation between flow and survival was not apparent at the lower range of

[90] See Kimmerer (2002) for a thorough discussion the history of and basis for $X_2$.

flows that usually occur. Following negotiations by parties involved, a 12 year Vernalis Adaptive Management Program (VAMP) was designed to investigate the influence of flow and exports on the survival of fall-run smolts moving into the Delta from the San Joaquin River. The VAMP uses hatchery fish marked with coded-wire tags, released above and below the reach most affected by the pumps: upstream releases at Durham Ferry (rkm 109 ) and Mossdale (rkm 90), and downstream releases at Jersey Point. Recoveries are at Antioch (rkm 9) and Chipps Island. The experimental design of the VAMP calls for targeting flow and export combinations for a 31 day period between April 15 and May 31 (Table 16-1), although as a practical matter flows in the San Joaquin vary around the selected target by around 10 $m^3s^{-1}$. Results to date are inconclusive (Figure 16-1). The estimated survivals through the lower river seem low, given that runs persist in San Joaquin tributaries.

Table 16-1. Combinations of exports and flow into the Delta from the San Joaquin River that are targeted by the Vernalis Adaptive Management Program (VAMP).

| Flow ($m^3s^{-1}$) | Exports ($m^3s^{-1}$) | | |
|---|---|---|---|
| | 42.5 | 63.7 | 84.9 |
| 90.6 | X | | |
| 127.4 | X | | |
| 161.4 | | X | |
| 198.2 | X | | X |

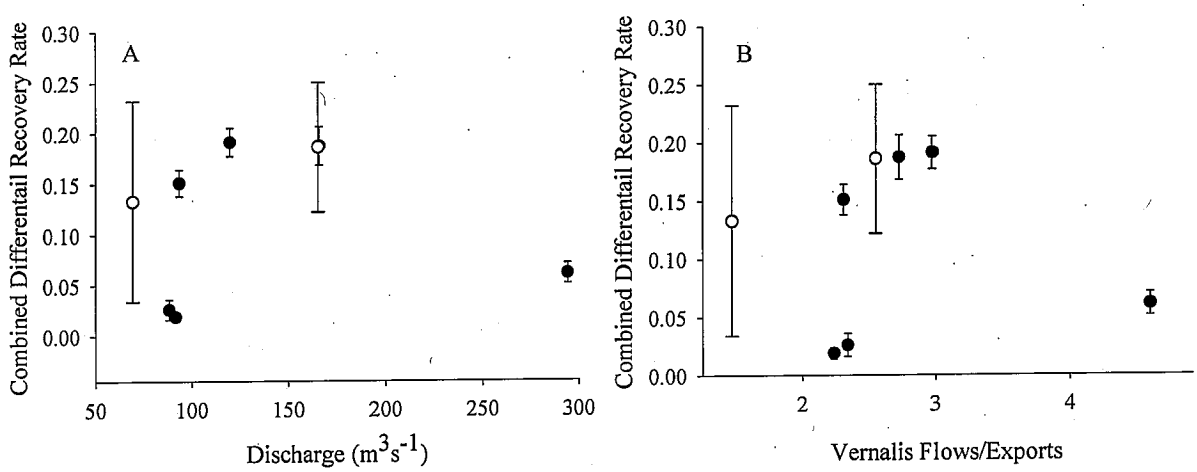



Figure 16-1. Combined differential recovery rate (a measure of survival) plotted (a) over discharge at Vernalis, and (b) the flow/export ratio, for the years of the VAMP experiment, 2000-2005 (filled circles) and two prior years, 1994 and 1997 (open circles). The two low survival years are 2003 and 2004. The combined differential recovery rate is the ratio of the recovery rates for the upstream and downstream release groups, which in turn are the ratios of the recoveries at both recovery sites to the number of fish released upstream. Bars show one standard error. Data from SJRGA (2004) and Lowell Ploss.

In general, the trend in management of the hydrosystem has been toward increased accommodation of environmental concerns, and the legal and institutional means for this trend to continue are in place. Whether the trend will continue is uncertain. The basic problem is that the increasing human population and climate change will place increasing stress on both the system and the web of legal and institutional arrangements by which it is managed. Warmer winters will mean that more precipitation will fall as rain, during individual storms as well as over the season, so to maintain the same level of flood control, dams may need to be drawn down farther in the winter, and there will be less snowmelt runoff to fill them in the spring. Like the Red Queen in Alice and Wonderland, hydrosystem management will need to run faster and faster just to stay in the same place.

# CHAPTER 17

# SUMMARY AND RECOMMENDATIONS

*The impression that it is sought to convey throughout this paper is that in order to conserve our fisheries, there are many problems to be solved, all of them important. Among them that of the adoption of statistical methods having for their object the ascertainment of the abundance, rather than the amount taken, easily comes first. But such a substitution cannot be made without a knowledge of biology to supplement and guide it. And the biological phases of fishery science are in themselves many and important, dealing as they do with the rate of growth and movements of the fish. Then, finally, there is almost no adequate knowledge concerning the methods of conservation, or the prevention of depletion. We are at the threshold of a period of exploitation of our fisheries and we must be sure to begin an era of scientific investigation of our fisheries in time to adequately guide and control the exploitation.*

*W. F. Thompson (1919:59)*

This chapter provides a brief summary of the main points presented in earlier chapters, followed by a summary review of the current status and future prospects of the various runs of Chinook and of steelhead. Some recommendations relevant to each of the runs are given, followed by general recommendations regarding management of salmon and their habitats.

## Summary

For thousands of years, since the post-Pleistocene rate of increase in sea level slowed and allowed the formation of vast tidal wetlands in the Delta, five species of Pacific salmon in the Central Valley adapted to conditions more or less like those existing when the gold rush began (Ch. 3). Occasionally, salmon in the Central Valley were subject to severe stresses, such as major episodes of drought around 1,000 and 700 years ago (Stine 1994), but evidently they survived. By the time of the first serious study of salmon at the end of the nineteenth century, however, Central Valley rivers had already been heavily modified by hydraulic mining, dams and diversions, levees, clearing and snagging, and logging. Pink, chum, and coho salmon were effectively extinct in the Central Valley, as were many of the pre-existing populations of Chinook and steelhead, and perhaps also summer-run Chinook in the San Joaquin River (Ch. 2). Statements about the life histories and habitat use of natural salmon populations in the Central Valley are therefore more or less speculative, as are statements about their abundance, although from the historical accounts there is no doubt that Chinook were abundant, and from the documentation of the natural landscape such as the Map of Public Surveys and inferences about the habitats that it offered, it is not hard to imagine why; the Central Valley was a good place to be a salmon (Ch. 3).

Modifications of Central Valley rivers continued through most of the twentieth century. Impassible dams were built on all major Central Valley rivers where the rivers emerge from the foothills, fundamentally changing the hydrologic conditions in the moderate to low gradient

reaches downstream from the dams where Chinook and steelhead are now mainly confined. The loss of upstream habitat and other changes such as loss of wetlands, increased diversions, bank stabilization and gravel extraction are detrimental to salmon, but not all modifications of the rivers were adverse. Particularly in the Sacramento system, water is released from dams into the channels rather than into canals for conveyance to users, and this creates habitat that to some degree substitutes for habitat above the dams that has been lost to salmon. For example, winter Chinook now reproduce in parts of the Sacramento River that formerly were far too warm during their summer spawning season, and for a time, until the Red Bluff Diversion Dam (RBDD) went into operation, this substitute habitat was highly productive. Problems associated with the RBDD have been reduced by keeping the dam gates open for much of the year, but the productivity of the habitat with current salmon populations remains uncertain, as explained below.

Based on analysis of functionally neutral genetic markers, five distinct groups of Chinook populations persist in the Central Valley: fall-run, late fall-run, winter-run, and two groups of spring-run. These are grouped into three Evolutionarily Significant Units (ESUs) for purposes of the federal Endangered Species Act (ESA): fall-run (including late fall-run), winter-run, and spring-run. Of these, winter-run are listed as endangered under the ESA, and spring-run are listed as threatened. The spring-run ESU includes a population in the Feather River that groups very close to fall-run in genetic analyses. The remaining steelhead are winter-run (sometimes called fall-run), although formerly there were also summer-run. However, existing Central Valley steelhead populations in the American and Mokelumne rivers are derived from a coastal population that was introduced into hatcheries on those rivers (Ch. 2). Central Valley steelhead are also listed as threatened under the ESA.

Naturally reproducing Central Valley salmon pass through a series of environments during their lives, beginning in the gravel-beds of streams, and continuing through the lower gradient reaches of the streams, the San Francisco Estuary, the Gulf of the Farallones, the ocean, and back again (Chapters 6-11). All of these habitats have been highly modified (Ch. 3).[91] Salmon have responded to these changes in various ways. Demographically, their numbers vary from year to year, depending both on natural variation in climate, ocean conditions, etc., and on variation in human activities such as harvest, hatchery production, and water management. Chinook populations have always varied substantially (Dettman et al. 1987), but, at least for fall Chinook in the Sacramento River and its tributaries, have done so particularly in the last two decades, from extreme lows around 1990 to much higher numbers around 2000 (Ch. 2).

Genetically, salmon have responded to the changed conditions in the Central Valley over tens of generations, enough time for considerable evolution to occur. As one example, age at maturity is genetically influenced, and the range of age at maturity in Chinook has decreased by about a year, presumably in response to selection by ocean harvest; 85 years ago there were many five year-olds and a few six year-olds, and now there are many four year-olds and a few

[91] From a salmon's point of view, ocean habitats have been highly modified in the last century by the appearance of a major new predator that also harvests small fish on which salmon feed.

five year-olds. Size increases with age, so on average Central Valley Chinook are now smaller as well as younger (Ch. 13). Other changes have not been documented, but probably for lack of baseline data rather than absence of changes.

Developmentally, salmon may follow one or another life-history pattern, depending on both natural and anthropogenic conditions as well as on their genotypes. Currently, the great majority of naturally produced juvenile Chinook in the Sacramento River and its tributaries begins migrating downstream shortly after they emerge from the gravel, mainly in late winter or early spring, although some rear in the streams for a few months to a year before emigrating in late spring or in the following fall, winter, or spring (Ch. 2). The propensity to migrate at different times varies among runs and among populations, and among years. For example, in the San Joaquin tributaries, juvenile fall-run migrate mainly in winter in some years and in spring in others. Spring-run in several Sacramento River tributaries, the last wild salmon in the Central Valley, exhibit great diversity in life history patterns. Various cues, including the Earth's magnetic field, the angle and duration of sunlight, and the specific odors of different streams, are used to accomplish the required navigation and scheduling for these migrations, although just how it is accomplished remains unclear (Ch. 5). Similarly, although a good deal is known about the control of salmonid life history patterns (Ch. 1), just what determines the repertoire of behaviors used by Central Valley salmon to survive, grow and reproduce in these various habitats remains uncertain.

Whether or not "mitigation, protection, and restoration of fish and wildlife" have become co-equal with water supply as purposes of the Central Valley Project, as called for by the Central Valley Project Improvement Act (CVPIA), there is no doubt that in recent years salmon have been given much more consideration in the management of Central Valley rivers than was formerly the case (Ch. 16). Moreover, the conceptual foundation underlying salmon management is changing. The CALFED environmental restoration program, with an emphasis on restoring populations by restoring the natural processes that create habitat for the populations is one aspect of this change, which provides a basis for optimism regarding the future of salmon and steelhead in the Central Valley. Other aspects of salmon management, especially hatcheries and harvest, reflect an older, production-oriented approach based on an agricultural model (Ch. 1). Management actions based on these different points of view will be in conflict until a clear set of priorities is developed.

As one example, hatcheries now provide habitat for a large percentage of Central Valley Chinook and steelhead. In one sense the hatcheries have been successful, especially for fall Chinook, as evidenced by the very high returns in recent years. However, hatcheries have come under increasing criticism (Ch. 12). The National Resource Council (NRC 1996) identified demographic risks, genetic and evolutionary risks, behavior, fish health, physiology, and ecological problems as issues concerning the interaction of hatchery and naturally produced salmon. Genetic risks seem most serious, since genetic effects will persist even if hatchery production is ended. A group of distinguished scientists recently asserted that "Inevitably, hatchery brood stock show domestication effects, genetic adaptations to hatchery environments

that are generally maladaptive in the wild" Myers et al. (2004:1980), and there is evidence, discussed below and in Ch. 2, that hatchery fall Chinook have tended to replace naturally reproducing fish in the Central Valley, rather than supplement them. Thus, hatchery production tends to undercut the CALFED objective of promoting locally adapted, naturally reproducing populations of Chinook and steelhead.

As another example, there is little doubt that harvest is slowing the recovery of winter and spring Chinook. Almost a quarter of subadult winter-run were killed by the ocean fishery in 1998-2000, as were over a third of subadult spring-run in 1998 and 1999 (Feb. 2004 Interagency Workgroup Report to the PFMC, cited in CDFG 2004a and 2004b). Not all of these would have survived to spawn. Nevertheless, given the high mortality rate of small fish in the ocean, the ~1% of juvenile winter-run that are killed at the Delta pumps pales into insignificance by comparison.

Salmon monitoring in the Central Valley is conducted by a number of agencies or their consultants (Ch. 15). Coordination among the monitoring programs has improved in recent years, but the programs do not constitute a well integrated system, and primarily address questions based in the older production-based approach to salmon management.

The greatest threat facing Central Valley salmon is the projected warming of the regional climate (Ch. 3). The high mortality of adult spring-run in Butte Creek in two recent summers (Ch. 6) underscores this problem. Although the details remain uncertain, the world is getting warmer (Hansen et al. 2005; Barnett et al. 2005), and California increasingly will get less precipitation as snow (Mote et al. 2003; Hayhoe et al. 2004). Based on an analysis of an ensemble of climate models and emission scenarios and a reference temperature from 1951-1980, the most plausible projection for warming over Northern California is 2.5°C by 2050 and 5°C (9°F) by 2100, with a modest decrease in precipitation (Dettinger 2005). Climate change will complicate all the CALFED programs, but Chinook in the Central Valley are at the southern limit of their range, and it seems unlikely that any could survive a 5°C warming. These projections depend heavily on assumptions about future emissions of greenhouse gases, however, and because there are many other compelling reasons to reduce emissions, there may still be time to moderate warming enough to allow salmon to persist in the Central Valley.

**The current status and future prospects of Chinook and steelhead in the Central Valley**

*Fall Chinook*

The typical life history patterns of fall Chinook avoid freshwater during the summer, with juveniles migrating toward the Delta within a few days to a few months of emerging from the gravel. Much of the natural spawning habitat for fall-run is downstream from dams, habitat conditions on many streams seem good in many years, and large numbers of naturally spawned juveniles are produced in many years.

Fall-run returns have increased dramatically over the last decade, but much of the increase probably results from improved ocean conditions, together with stable hatchery production and

sharply reduced harvest. Few hatchery fall-run are marked, so the proportion of hatchery fish among returning adults is unknown, but presumably it is large (Ch. 12). The NOAA Fisheries status review concluded regarding fall Chinook that "...high hatchery production combined with infrequent monitoring of natural production make assessing the sustainability of natural production problematic, resulting in substantial uncertainty regarding this ESU" (Myers et al. 1998). This uncertainty remains.

There is good reason to believe that salmon populations that breed both in hatcheries and in streams can lose fitness for breeding in streams (Ch. 12; Hey et al. 2005), and that hatchery salmon may tend to replace rather than supplement naturally producing fish in consequence of this and of density-dependent mortality (Cooney and Brodeur 1998; Hilborn and Eggers 2000; Sweeting et al. 2003). Such replacement has been demonstrated for a Chinook population in New Zealand (Unwin and Glova 1997), and there is evidence from the Sacramento River system that it is happening in the Central Valley. Enough marked fall-run have been found recently in Mill and Deer creeks to indicate that these populations are largely hatchery strays (Ch. 2). A century ago, Mill Creek was known for its large run of fall Chinook, and its watershed is still largely undeveloped, so the heavy presence of hatchery fish there is an ominous sign. Recent trends in returns to Battle Creek and to the mainstem river also suggest replacement (Figure 2-5). Assuming that the number of Coleman Hatchery fish that stray to the mainstem Sacramento River roughly balances the number of naturally produced fish returning to Battle Creek, so that the mainstem and Battle Creek returns approximate the naturally produced and hatchery fractions of the population, it appears that the hatchery fraction is now dominant. If the early estimates of returns reasonably reflect the actual returns, the total numbers of fall Chinook upstream from Red Bluff were about the same in the years around 1960 as they have been in recent years, but most fall-run now return to Battle Creek.

Some problems with hatcheries have been recognized and are in various stages of correction in the Central Valley; for example moving fish from one stream to another has largely been stopped, although CDFG policy still permits it. Some problems, such trucking fish around the Delta, which increases straying, could be stopped but have not been. Other problems, such as the lack of natural mate selection and the different selective regimes in hatchery and natural environments, probably cannot be avoided.

For fall-run, probably the greatest near-term need is to revise hatchery and harvest policies and practices to be more consistent with restoration objectives. Recommendations in this regard are given in Chapters 12 and 13, and below. Climate change is the greatest long term hazard, as it is with other runs. At the least, warming will shorten the period in which the low elevation habitats used by naturally producing fall-run are thermally acceptable. This should particularly affect fish that emigrate as fingerlings, mainly in May and June, and especially those in the San Joaquin River and its tributaries.

*Late fall Chinook*

Late fall Chinook spawn in winter, and the juveniles pass a summer in freshwater before emigrating in the fall. Less is known about late fall-run than about other runs of Chinook, for several reasons. First, they spawn when field work in the rivers is much more difficult than in other seasons, and since the RBDD gates have been raised seasonally the estimates of adult returns of late fall-run have been less reliable than for other runs. Second, until recently, it was not possible to distinguish individual late fall-run fish from fall-run fish using genetic markers, so confirming ideas about late fall-run has been very difficult. Third, because late-fall are included in the unlisted Central Valley fall-run ESU (Myers et al. 1998), there is less motivation to study them. There were good returns of late fall Chinook in 1998 and 2002, but they have not increased as strongly in recent years as other runs. Returns to the Colman National Fish Hatchery have increased in recent years relative to returns of naturally produced fish, and although the percentage of hatchery fish among natural spawners is still low, it seems to be increasing (Ch. 2).

More needs to be learned about late fall-run. A good first step would be regular genetic typing of subsamples of juvenile Chinook captured in monitoring programs. Initial questions that could be addressed include an assessment of which streams support late fall-run on a regular basis, whether populations in smaller streams are strongly influenced by hatchery strays, and whether there are differences in the life history patterns of naturally produced and hatchery fish. It is also important to learn whether juvenile late fall-run from the hatchery are reasonable surrogates for naturally produced Chinook from other runs, as assumed in some survival studies.

*Winter Chinook*

Winter Chinook have increased sufficiently over the last decade to ease concerns about their near-term prospects (Ch. 2). If the population continues to increase, the biological significance of reversible sources of mortality such as losses of juveniles at diversions will become increasingly questionable. The population is already large enough to raise questions about the desirability of hatchery supplementation, and to justify loosening restrictions on mortality in monitoring programs, especially those producing information that will be useful for managing winter-run or other listed runs or species. Besides ocean conditions and reduced harvest, changes in the management of freshwater habitat, especially raising the RBDD gates, probably account for most of the recent increase in numbers of winter-run, although probably hatchery supplementation has also helped. The long-term prospects for winter-run are still poor, however. For winter-run, the embryonic and larval life stages that are most vulnerable to high temperatures occur during the summer, so winter-run are particularly at risk from climate warming. Currently there is only a single population. Removal of dams on Battle Creek should allow for re-establishment of a second population there, but whether the Battle Creek habitat will remain cool enough to be suitable as the climate warms seems doubtful.

Now that the temperature of releases from Shasta can be better managed, the RBDD is operated seasonally, and passage over the ACID Dam has been improved, the actions that seem most likely to help winter-run in the short term are extending the "gates out" period at RBDD to include the beginning of juvenile migration period, further reductions in harvest, and

improvements to the habitat used by juveniles during their slow migration down the Sacramento River. Implementation of the "meanderbelt" concept between Red Bluff and Colusa (SRCAF 2003) through continued acquisition of riparian land or easements to allow more natural processes of channel behavior and habitat creation may be particularly important; most of the bank protection works in this reach were constructed from the 1960s to the 1980s (Greco 1999), when the winter-run population was declining. More needs to be learned about the way that juvenile winter-run use this habitat, but studying small fish in large rivers is difficult, and new approaches probably are needed. Collecting samples with seines by itself will be of limited value, absent well-defined questions that the sampling can reasonably be expected to answer.

Installing an operable gate with a fish ladder at the Fremont Weir, so that some water could be diverted into the Yolo Bypass in all years, should also be helpful. This would allow adults that are attracted into the bypass to continue their upstream migration, and make the toe drain a regular distributary of the Sacramento River, with better prospects for a more natural connection to a floodplain than are available for the main channel. Passage down the bypass also keeps migrating juveniles away from the central Delta and the pumps.

As far downstream as the RBDD, juvenile winter Chinook can be reasonably well identified using length at date criteria, but this will change if spring Chinook populations increase in upper Sacramento mainstem or tributaries. Below the confluences of Mill and Deer creeks the utility of these criteria deteriorates, because of overlap with spring-run, and fish or subsamples of fish should be assigned to runs by genetic analyses. Making genetic analyses a routine part of monitoring for juvenile Chinook will allow better understanding of the actual spatial and temporal distribution of juveniles of all runs. The existing data from the RBDD screw traps seem like a rich vein for exploratory data analyses. For example, the length and number of emigrating winter-run appear to be inversely related, suggesting a density-dependent effect (Figure 8-5). As patterns are identified they should be fit with models that can be tested with future data.

It is probably time to begin modeling the effects of different scenarios for climate change on water temperature in the Sacramento River, to allow assessment of their consequences for all runs.

*Spring Chinook*

Spring Chinook have made a spectacular recovery in Butte Creek in recent years and have increased in other streams as well, although the population in the mainstem Sacramento River apparently has dwindled to very low numbers (Ch. 2). Favorable ocean conditions, including reduced harvest, doubtless has contributed to the increases in the tributaries. Why spring-run declined in the mainstem Sacramento River is less clear, but interbreeding with fall-run seems the most plausible explanation. Why spring-run have increased more in Butte Creek than in Mill and Deer creeks is also unclear. Substantial efforts have been made to improve adult passage in Butte Creek, and this may have released the potential of inherently more productive habitat in Butte Creek, but the question remains why the habitat is more productive, if it is. The low elevation habitat in lower Butte Creek and the Sutter Bypass may be responsible, and the use of

this habitat by juvenile spring-run deserves continued study. In any event, the population in Butte Creek has been high enough in some recent years that strong density-dependent mortality seems inevitable, and further large increases should not be expected.

Despite recent increases in several populations, the prospects for spring-run are dampened by global warming. Spring-run in Butte Creek are limited to low elevation habitat that is thermally marginal now, as demonstrated by high summer mortality of adults in 2002 and 2003, and will become intolerable within decades if the climate warms as expected. The same is true for other streams such as Beegum Creek, a tributary of Cottonwood Creek, where modest numbers of spring-run have been observed in recent years. However, suitable conditions should persist longer in Mill and Deer creeks, where fish can reach higher altitudes. Some existing or potential habitat should also remain for some time below various dams that currently release cool water through the summer. More habitat could be opened up in Battle Creek if the proposed restoration plan for that stream is implemented; although it seems doubtful that the habitat will remain cool enough in the summer for the eggs of winter-run to survive if the predicted warming occurs, it may remain cool enough to provide holding habitat for adult spring-run, which are considerably more tolerant of warm water. Opening the Yuba River to spring-run is also under study. Temperature criteria developed from Butte Creek data should be used to evaluate the thermal suitability of habitats there, since temperature criteria developed from the literature are likely to be too conservative. On the other hand, the investigations should consider future as well as current temperatures.

Spring-run are restricted to low elevations in Butte Creek by natural barriers as well as PG&E dams. The Butte Creek canyon is so steep that opening access to higher elevation habitat would be difficult, but the possibility of doing so should be reassessed in light of global warming. In the meantime, consideration should be given to trucking a few adults around the PG&E dams to avoid losses of complete year classes, as may have happened in 2002, although the trucking would work only if the PG&E diversions were screened.

Chinook return to the Feather River in spring, but genetic analyses show that these are very closely related to fall-run (Figure 2-2). These fish hold over through the summer in the river, and until recently attempts at the hatchery to isolate them reproductively from fall-run have not been fully effective. Fish also appear in the Yuba River in spring, and it seems likely that these are similar. Whether or not these fish belong in the spring-run ESU, they do contribute to the phenotypic diversity of Central Valley Chinook, and so deserve attention, especially given the possibility that appropriate habitat for spring-run will become available in the Yuba River. In the meantime, a portion of the low-flow channel in the Feather River might be fenced off in early summer to keep these early fish spatially isolated from fall-run. The hatchery production target for Feather River spring-run has recently been reduced, from five to two million smolts. The appropriate level of hatchery production should be considered carefully, using analytical approaches such as those reported in Lynch and O'Hely (2001) or Goodman (2005).

Opening new habitat for reproduction raises the question whether fish from other streams should be introduced to seed the new habitat, or whether fish should be allowed to colonize it on their own. There is not an obvious answer to this question. Past transfers of fish from one stream to another are now commonly regarded as mistakes, and this history cautions against deliberate transfers. That is, we may think that we now understand enough to avoid past mistakes, but probably biologists in the past also thought that they understood enough to make wise choices. However, opening habitat that may not be colonized for decades does not seem feasible politically, even if it were desirable biologically. Where some fish are using the habitat, as in Clear Creek, it seems appropriate to give them a chance to colonize it. On the other hand, it seems far less likely that fish would spontaneously recolonize the San Joaquin River in any reasonable time, assuming that adequate instream flows are restored, so deliberate transfers seem appropriate.

*Steelhead*

The current status of naturally-produced anadromous steelhead in the Central Valley is poor; abundance data are scant, but based on the ratio of marked and unmarked smolts captured in the Chipps Island trawl, it appears that the anadromous populations total only a few thousand adults, and an unknown percentage of these are progeny of hatchery fish, some from an out-of-basin stock. On the other hand, if the non-anadromous component of the population is taken into account, the status of *O. mykiss* in the Central Valley is much less dire. Like spring Chinook, steelhead have been cut off from most of their natural spawning habitat on most Central Valley rivers by dams. Some of these dams, for example Shasta and New Melones, release enough cool water through the summer to provide good habitat for non-anadromous *O. mykiss*, and it appears that many fish are taking advantage of it. It is also possible that *O. mykiss* in Sacramento River tributaries such as Clear Creek have become potadromous rather than anadromous; that is, they may migrate downstream to the river, but not continue to the ocean.

Steelhead are heavily influenced by hatchery production in several rivers, with unknown consequences for the fitness of naturally spawning fish. This is particularly a problem on the American River, where the naturally spawning population is included in the Central Valley steelhead ESU although the hatchery population is not, but naturally spawning fish are mainly hatchery fish from a coastal stock (Hannon et al. 2002; 2003; Nielsen et al. 2005). If fish that really belong in the Central Valley ESU actually occur in the American River, then hatchery production is a major threat for them, and should at least be sharply curtailed. It seems more sensible to recognize that the steelhead in the American River are the legacy of a past mistake,[92] and to manage the river for fall Chinook instead. A similar situation exists in the Mokelumne River.

[92] When Nimbus Hatchery began operations it was unsuccessful at propagating the existing population of steelhead in the American River, and eggs from the northern California coast were introduced to found the existing population.

**General recommendations for management**

*1. Take climate change into account.*

Regional climate models are improving (Hayhoe et al. 2004), and before long may provide more specific forecasts that are usefully reliable for guiding management, but the reality of warming is certain enough that it should be factored into planning for restoration activities. As a practical matter, this means that restoration activities that will benefit multiple species or ecosystems should be preferred over those that are specific to salmon, especially along streams where water temperatures are less likely to remain tolerable for salmon. Restoration activities in lowland areas such as tidal marsh restoration should also take account of projected increases in sea level. Change in the amount and distribution of precipitation should also be expected, so designing restoration projects to match historical hydrology is problematic. This seems particularly so for restoration plans that aim to reconstruct floodplains to match miniaturized but more naturally variable hydrology downstream from dams; whether such plans are robust to plausible changes in climate should be considered before large amounts of money are committed to them.

Managers should resist the temptation to allow uncertainty regarding precisely how climate will change to be used to justify not taking future climate change into account in restoration planning. One reason for this is that uncertainty about the extent of global warming results mainly from uncertainty about future emissions of greenhouse gases (Hayhoe et al. 2004); ignoring climate change will likely make it worse.

*2. Recognize the limitations of concepts, and use multiple approaches to evaluate problems and policies.*

It is well known that the concepts of waves and particles can both be usefully applied to light, but that neither concept allows a complete description of its behavior. In a similar way, various conceptual models or analytical approaches can be usefully applied to salmon or habitats or ecosystems, but none allows complete or even generally sufficient descriptions of them. For example, concepts from population, behavioral, and physiological ecology might all be usefully applied to different aspects of some problem regarding salmon management. The saying that "all models are wrong, but some are useful" applies to conceptual models as well as other kinds, and different concepts or approaches will be more or less useful depending on the particular aspect of an issue that is under consideration. Which concepts or points of view are useful often depends on the spatial and temporal time scales involved, so problems and policies should be considered in terms of various spatial and temporal scales.

*3. Take evolutionary considerations into account.*

Evolution can occur rapidly in salmon populations. For example, a stream-type life-history pattern has developed in Chinook populations in New Zealand that were founded from ocean-type, fall-run fish about 100 years ago, as have other differences in life history patterns among Chinook in different New Zealand Rivers (Quinn et al. 2000; Quinn et al. 2001). In a statement supported by citations to studies of salmon as well as other organisms, Stearns and Hendry (2004:15) observed that "A major shift in evolutionary biology in the last quarter century is due

to the insight that evolution can be very rapid when large populations containing ample genetic variation encounter strong selection (citations omitted)." Management can impose strong selection, and managers should consider the consequences.

*4. Take populations and their habitats as the unit for management.*

The different runs of salmonids in the Central Valley, and the different life history patterns expressed by the runs, historically were associated with and presumably represented adaptations to particular habitats. If the runs and diversity in life history patterns are to be maintained, access to these habitats or their equivalents must be preserved or restored (Healey and Prince 1995). As a consequence, highest priority should be given to restoration actions that match fish with appropriate environments; for example, restoring access for steelhead to the South and Middle Yuba should have higher priority than managing temperature in the lower American River for steelhead, where the habitat is more appropriate for fall Chinook (and the existing steelhead population is derived from an out-of-basin stock). Maximizing access for winter-run and spring Chinook and steelhead to appropriate habitat in Battle Creek, and providing seasonal access for juvenile salmon to flooded overbank habitat, e.g., in the Yolo Bypass, should also have high priority.

Lichatowich (1998) noted that stocks have been the traditional unit of management, but, building on Healey and Prince (1995), argued that the management units need to be stocks and their habitats. Booke (1999) similarly argued that acceptable stock concepts must be based on inherited markers that define a specific group of fish plus its habitat. In practice, however, management convenience has sometimes resulted in the development of multi-population stocks such as Sacramento River Fall Chinook. Restoration, on the other hand, typically deals with habitats that are occupied by particular populations, and these habitats and populations should be the basic units of management.

*5. Take account of the evolutionary and ecological effects of hatcheries and harvest, as well as the demographic effects.*

In a recommendation that seems well directed to CALFED, NRC (1996:321) advised that "The approach to hatchery operations should be changed in accordance with the goal of rehabilitation and the ecological and genetic ideas that inform that goal." This is a major undertaking. To this end, CALFED should sponsor a major review of Central Valley hatcheries in which all options are up for consideration; these include sharply reducing hatchery production, consolidating hatchery production to one or two streams, moving Chinook hatcheries to coastal streams without natural populations, and abandoning hatchery production altogether (Ch. 12). In the meantime, all hatchery fish should be marked, as recommended by NRC (1996) and as legally required for salmon intended for harvest that are produced by federally funded hatcheries.[93]

[93] Public Law 108-7, enacted in Feb. 2003, contains the following language in sec. 138: "The U.S. Fish and Wildlife Service shall, in carrying out its responsibilities to protect threatened and endangered species of salmon, implement a system of mass marking of salmonid stocks, intended for harvest, that are released from Federally

The ocean troll fishery inherently selects against more slowly maturing fish, because it targets subadult as well as maturing fish (Clark 1929; Ricker 1980). The available evidence indicates that ocean harvest of sub-adults has narrowed the range of age at maturity for Central Valley Chinook by about a year. A shift to a terminal fishery, for example using gill nets in the bays, may be necessary to avoid continued selection against late-maturing fish, and continued decrease in average age at maturity. In the past, the California Fish and Game Commission favored a terminal fishery over the troll fishery for such reasons (Scofield 1929). Commercial harvesting in a terminal fishery would also allow a much tighter focus on unlisted runs, although the early season recreational fishery has the greatest impact on winter-run (CDFG 2004a). At the least, a shift to a terminal fishery deserves serious study.

PFMC objectives for adult returns should be harmonized with CALFED objectives. Goals for adult returns should be revised and put on a scientifically supportable basis. In particular, separate goals for adult returns should be set for naturally produced fall Chinook in major streams, including the San Joaquin River tributaries. Goals should be set in terms of the expected number of progeny, which would give more weight to larger females.

*6. Treat management as experimental, and try to learn from it.*

The California Department of Fish and Game recently suspended stocking trout in a sample of alpine lakes in the Sierra Nevada, and studied whether the existing populations were able to maintain themselves by natural reproduction (Armstrong and Knapp 2004); by and large they were, and comparisons of otoliths from fish in stocked and unstocked lakes indicated that density-dependent reductions in growth rates occurred in the stocked lakes. CALFED has properly emphasized the importance of such active adaptive management, in which actions are taken deliberately to perturb the system being managed, in order to learn from its response. For example, hatchery production of Chinook might be sharply reduced for some number of years to test whether there are density-dependent interactions between hatchery and naturally produced fish, such that increased productivity of the naturally produced fish would compensate for part or all of the foregone hatchery production. Unfortunately, the scarcity of good examples of active adaptive management demonstrates how difficult such management experiments are to arrange, and particularly in the short term, the political feasibility of active adaptive management does not seem likely to increase.

Deliberate management experiments are necessary where there is otherwise little variation in some variable that is central to the problem at hand, such as the hatchery production of juvenile salmon and steelhead. For many problems, however, there is substantial variation in the important variables because of natural variability in climate, and this makes a more passive approach to adaptive management viable. The critical element for success in such passive adaptive management is a state of mind: looking always for opportunities to learn. This leads to

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operated or Federally financed hatcheries including but not limited to fish releases of coho, chinook, and steelhead species."

thinking of management actions as experiments, formulating hypotheses, and trying to conduct monitoring that is adequate to get the experimental results and test the hypotheses. Monitoring should be approached from this point of view.

*7. Simulate major restoration actions and monitoring programs.*

Restoration actions are expensive experiments. CALFED has properly stressed the importance of articulating the conceptual model or hypotheses upon which proposed actions are based. For actions of any magnitude, it should be worthwhile to develop a numerical formulation of the conceptual model so that likely outcomes of the action can be evaluated quantitatively, and the sensitivity of the outcomes to various parameters in the model can be assessed. This process can help identify key uncertainties and avoid expensive mistakes. The Clear Creek Decision Analysis and Adaptive Management Model (Alexander et al. 2003) that has been developed with CALFED funding is an example of this approach; unfortunately, as that example demonstrates, such modeling can be very difficult. The Water Use Planning (WUP) process in British Columbia, more or less a Canadian equivalent of the FERC relicensing process, provides more successful examples (e.g., McDaniels and Gregory 2004).

In many cases, the monitoring that is proposed to accompany the action should also be simulated, with appropriate random noise added to simulate measurement uncertainty, to determine how strong a signal the restoration action must generate to be detected with reasonable probability. Monitoring programs not associated with specific restoration actions should also be simulated. Ludwig and Walters (1985) urged that "all estimation schemes should be tested with simulated data where the parameter values are known in advance, since accuracy and consistency cannot in principle be determined from 'real data' where parameter values are unknown." Williams (1999) used such simulations to show the limitations of the salmon monitoring proposed by the Comprehensive Monitoring and Assessment Program (CAMP). This should be standard practice, especially for major efforts such as the VAMP.

Developing a larger group of modelers and statisticians to work on Central Valley salmon issues would be a major step forward. Ideally, this group should be large enough to raise the general standard of numeracy among Central Valley salmon biologists, but small enough that it remains focused on issues of importance to other biologists and managers, rather than on modeling itself. It is also important that training opportunities be offered to biologists who are less well versed in statistics and data analysis, so that good communication is possible.

*8. Take account of developments in other areas of biology that may help address questions regarding salmon biology and management.*

The development of genetic markers for the various runs of Chinook has substantially improved understanding of questions concerning take of listed Chinook at the Delta pumps, and should allow better understanding of the migratory behavior of the various runs as genetic typing is incorporated into existing monitoring programs. With a few exceptions, however, the markers are not associated with traits conferring fitness. The development of a "gene chip" for salmon (Rise et al. 2004) may provide a means to address other genetic questions that do involve fitness.

For example, it may be possible to determine whether domestication has occurred in hatchery fish by examining whether patterns of gene expression in the face of low oxygen levels or other stresses are the same in wild fish and in fish with long histories of hatchery culture. Appropriate advantage should be taken of this and other technological advances.

*9. Put the effects of the pumps on Chinook and steelhead into proper perspective.*

It seems clear that the Delta pumps are a problem for Central Valley Chinook, especially for San Joaquin River Chinook, and presumably the problem will increase as pumping increases. Nevertheless, it does not appear that the pumps *per se* are **the** problem. Probably because of the assumption that juvenile salmon would passively follow the water (e.g., Erkkila et al. 1950), the pumps have received more attention as a factor in the decline of salmon and other fishes than seems justified by the available evidence. That said, it seems artificial to consider the pumps separately from truncated habitat, reduced spring flows, freshening of the Delta, and other changes in Central Valley salmon habitats that result from the entire system for water management, of which the pumps are an important part. The critical point is that Central Valley salmon would benefit from a more rational allocation of management attention over problems.

*10. Put human intervention into proper perspective.*

Restorationists have properly emphasized the desirability of maintaining or re-creating conditions such that natural processes maintain habitat in which wildlife can go about its business without human intervention. Thus, for example, CALFED has emphasized the importance of allowing high flows to power natural fluvial processes that sort bed sediments in streams and create spawning habitat. This is the best approach for protecting Chinook and steelhead in the Central Valley, as with the meanderbelt concept, mentioned above. However, the prevalence of dams on Central Valley rivers and human intervention in global climate limit the practicable scope for this approach, and alternatives should be entertained where it is not feasible. For example, on heavily regulated rivers where it is not feasible to provide "flushing flows," mechanical cleaning of spawning gravels should be considered, if gravel quality is a problem. Similarly, where dams prevent natural spatial segregation between runs, artificial separation is necessary if the distinct runs are to be maintained. For example, fall-run are now restricted to the valley reach of Clear Creek, to protect spring-run that spawn farther upstream in the canyon reach. Potentially, this approach could be followed on the Sacramento and Feather rivers, as well, if the fish ladder on the ACID Dam were closed say from the end of July to when the dam is removed in October, or if fall-run were blocked from part of the low-flow channel of the Feather River. In other words, the desirability of restoring ecological functions does not justify an ideological opposition to direct human intervention in the affairs of Chinook and steelhead when there is no good alternative. However, it should be a last resort.

11. *Allocate streams to different treatment groups.*

Central Valley streams vary in the extent to which they have been modified or degraded, and have different prospects for restoration, so it makes sense to treat them differently. Although this variation probably is more continuous than discrete, it seems useful to consider three basic treatment groups to which different restoration approaches or objectives should be applied.

Restore selected streams to a semblance of natural conditions. For several streams, restoration to an approximation of natural conditions seems feasible, and should be pursued. An approximation of natural conditions does not mean pristine, and this objective does not require curtailing all diversions or ending human occupancy and use of the land along the streams, but it does mean trying to maintain or restore the main features and functions of natural stream ecosystems. Mill Creek and Deer Creek are the obvious candidates; the significant problems with these streams are concentrated at their lower ends and seem tractable, and a major restoration program is planned for Battle Creek. This objective also seems feasible for Butte Creek and for the Cosumnes River. In a sense, the conceptual foundation for this treatment is "If it's natural, it's right," although biological, practical and legal considerations will require that this be relaxed more or less frequently. Management should still be adaptive, with explicit hypotheses and monitoring for restoration work, but rehabilitation of natural conditions and processes would be the default objective.

Restoration actions appropriate for this set of streams include acquiring land or easements along the streams from willing sellers; providing substitute sources of water for diversions, especially during critical periods; removing or modifying dams that block or impede migration; removing inappropriate bank stabilization works, setting back or removing levees, and rebuilding bridges with longer spans to allow passage of tree trunks.[94]

Select other streams for intensive restoration or active adaptive management of instream flows. Focusing active adaptive management efforts in some streams should make it easier to do things on a large enough scale to get clear responses. Streams should be selected primarily in terms of opportunity for large-scale restoration, or suitability for experimental management. The Yuba River, for example, apparently offers the best opportunity for restoration of holding and spawning habitat for spring-run salmon and access to tributary habitat for steelhead, although a recent court decision may result in the reintroduction of spring-run to the San Joaquin River below Friant Dam (Appendix C). The "low flow" channel of the Feather River, between Oroville Dam and the return from the Thermalito Afterbay, seems well suited for instream flow experiments. The river is large enough to be a reasonable model for other Central Valley streams, but it is small enough to allow populations to be monitored with reasonable accuracy, and flows are normally well controlled. Some streams may be suitable for an active adaptive approach to certain questions, but not to others, so this grouping should be flexible. For example, the installation of a temperature control device has made the water temperature in the lower American River controllable to a useful degree, so that stream is well suited for temperature-related experiments in the summer and fall, but it is less suited for flow-related experiments.

Apply passive adaptive management or more "status quo" management to the remaining streams, at least for the time being. Passive adaptive management can be effective when there is

[94] It is also important to stop cutting fallen trees into smaller pieces, as was done recently along Butte Creek (Williams et al. 2002).

substantial variation in the factor of interest. For example, flow in most Central Valley rivers varies more from year to year variation in the weather than it would from any plausible experimental variation, so passive adaptive management seems appropriate for flow-related questions, and is much easier and less expensive to implement than active adaptive management. Passive adaptive management nevertheless requires clear hypotheses and good monitoring to be effective, so in subtle but important ways it is quite different from traditional or status quo management. Good monitoring is difficult and expensive, however, and within this group of streams it should be concentrated where it is most likely to be effective. This means that some streams may be left with status quo management and minimal monitoring. Restoration will be difficult enough in the best of circumstances. Adding a requirement of geographical "fairness" to the program will make it that much more difficult.

*12. Develop a unified and consistent conceptual foundation for salmon management.*

Salmon management in the Central Valley, as in most other areas, suffers from a kind of schizophrenia. Much of it, especially hatchery and fisheries management, is still based on a production perspective, but much of it is now often based on a population perspective.[95] This schizophrenia is well reflected in the CVPIA, which mandated efforts to increase the populations of naturally-produced anadromous fishes by a program that gives "first priority to measures which protect and restore natural channel and riparian habitat values," but at the same time provided for rehabilitation and expansion of the Coleman National Fish Hatchery. Similarly, CALFED is undertaking an ecosystem-based restoration program, in part to restore depleted and listed stocks of Central Valley Chinook, while state and federal agencies maintain industrial-scale hatcheries that support mixed-stock fisheries.

The very high returns of fall Chinook in recent years that resulted in high rates of prespawning mortality in streams with hatcheries (e.g., Table 12-3) provides a clear example of objectives in conflict. The ocean fishing season has been sharply cut back in order to reduce harvest of winter-run and spring-run, and of Chinook from the Klamath River. However, hatchery production has been maintained at the same level, either to support high catch rates during periods when fishing was allowed, or from management inertia. The result has been so many hatchery fish spawning in the rivers that the spawning success of naturally produced fish has been compromised. Given the evidence that hatchery fish are genetically less well adapted to natural conditions (Ch. 12), there is a conflict between the objectives of trying to support the coastal fishing industry, and trying to allow recovery of the genetic integrity of Central Valley fall-run. This conflict may have a partial physical solution, in moving hatcheries to coastal streams that do not support wild Chinook, but ocean harvest of sub-adults will continue to select against more slowly maturing fish. Hatchery release practices provide another example of conflicting objectives. On the one hand, trucking smolts around the Delta results in more sub-adults in the ocean and more adult returns than releasing smolts at the hatcheries. However, the resulting increased straying rate will tend to obliterate any local differentiation and adaptation that may still exist, or to prevent them from redeveloping.

[95] Population and production perspectives are described in Ch. 1.

Because management actions based on these differing perspectives can be at cross-purposes, it is important that managers be given clear guidance on priorities. This can best be done by developing a unified and consistent conceptual foundation for the management of Central Valley rivers and the salmon that inhabit them. This review has advocated a population perspective, and clearly I hope that such a point of view will be adopted, but in fairness to the people who are expected to implement our policies, the temptation to finesse conflicts among management objectives should be resisted.

Reference List

2002 EWA Review Panel. 2002. http://science.calwater.ca.gov/pdf/EWAReviewFinal_1-27-03.pdf

Aceituno, ME. 1990. Habitat preference criteria for fall-run Chinook holding, spawning, and rearing in the Stanislaus River, California. Sacramento, California: U. S. Fish and Wildlife Service.

Aceituno, ME. 1993. The relationship between instream flow and physical habitat availability for Chinook salmon in the Stanislaus River, California. Sacramento, California: United States Fish and Wildlife Service.

Achord, S, Levin, PS, Zabel, RW. 2003. Density-dependent mortality in Pacific salmon: the ghosts of impacts past? Ecology Letters 6:335-342.

Adams, SM, Brown, AM, Goede, RW. 1993. A quantitative health assessment index for rapid evaluation of fish condition in the field. Transactions of the American Fisheries Society 122:63-73.

Adkison, MD. 1995. Population differentiation in Pacific salmon: local adaptation, genetic drift, or the environment? Canadian Journal of Fisheries and Aquatic Sciences 52:2762-2777.

Alabaster, JS. 1989. The dissolved oxygen and temperature requirements of king salmon, *Oncorhynchus tshawytscha*, in the San Joaquin Delta, California. Journal of Fish Biology 34:331-332.

Alderdice, DF, Wickett, WP, Brett, JR. 1958. Some effects of temporary exposure to low dissolved oxygen levels on Pacific salmon eggs. Journal of the Fisheries Research Board of Canada 15:220-250.

Alexander, CAD, Marmorek, DR, Peter, CN, Porter, M. 2003. Clear Creek decision analysis and adaptive management model: design document, draft 1.5. Vancouver, B. C.: ESSA Technologies.

Allen, MA. 2000. Seasonal microhabitat use by juvenile spring Chinook salmon in the Yakima River basin, Washington. Rivers 7:341-332.

Anderson, J, May, B, Williams, J, Lindley, S, Greene, S, Hanson, C, Low, A, McEwan, D, MacFarlane, R, Swanson, C, Yoshiyama, R, Teel, D, Banks, M, Williamson, K, Arden, W, Werner, I, Ainley, D, Viele, DCS, Kondolf, M, Grimaldo, L, Sommer, T, Killam, D, Brown, M, Ward, P, Hamilton, A. In press. Report from the Central Valley Technical Recovery Team Salmon Workshop. To be published as a NOAA Technical Memorandum.

Anderson, JJ. 2003. Toward a resolution of the flow/survival debate and the impacts of flow augmentation and water withdrawal in the Columbia/Snake River system. Seattle: Columbia Basin Research, School of Aquatic and Fishery Science, University of Washington.

Arkoosh, MR, Johnson L., Rossignol, PA, Collier, TK. 2004. Predicting the impact of perturbations on salmon (*Oncorhynchus* spp.) communities: implications for monitoring. Canadian Journal of Fisheries and Aquatic Sciences 61:1166-1175.

Armand, DF, Lannan, J, McNeil, WJ, Smith, C, Wedemeyer, GA. 2000. http://www.steelheadclub.com/pdfdocs/Perspectiveonhatcheries.pdf

Armstrong, TW, Knapp, RA. 2004. Response by trout populations in alpine lakes to an experimental halt to stocking. Canadian Journal of Fisheries and Aquatic Sciences 61:2025-2037.

Ashley, MV, Wilson, MF, Pergams, ORW, O'Dowd, DJ, Gemde, SM, Brown, JS. 2003. Evolutionarily enlightened management. Biological Conservation 111:115-123.

Atwater, BF. 1980. Attempts to correlate the late Quaternary climatic records between San Francisco Bay, the Sacramento-San Joaquin Delta, and the Mokelumne River, California [dissertation]. Newark: University of Delaware.

Atwater, BF. 1982. Geologic maps of the Sacramento-San Joaquin Delta, California. San Mateo, California: U. S. Geological Survey. MF-1401.

Azevedo, RL, Parkhurst, ZE. undated. The upper Sacramento River salmon and steelhead maintenance program, 1949-1956. United States Fish and Wildlife Service.

Bacon, CR, Weber, PK, Larsen, KA, Reisenbichler, R, Fitzpatrick, JA, Wooden, JL. 2004. Migration and rearing histories of Chinook salmon (*Oncorhynchus tshawytscha*) in ion microprobe Sr isotope and Sr/Ca transects of otoliths. Canadian Journal of Fisheries and Aquatic Sciences 61:2425-2439.

Baiocchi, JC. 1980. Use it or lose it: California Fish and Game Code Section 5937 and instream fishery resources. U. C. Davis Law Review 14:431-460.

Baker, PF, Morhardt, JE. 2001. Survival of chinook salmon smolts in the Sacramento-San Joaquin Delta and Pacific Ocean. In: Brown, RL, editor. Fish Bulletin.2. p. 163-182.

Baker, PF, Speed, TP, Ligon, FK. 1995. Estimating the influence of temperature on the survival of chinook salmon smolts (*Oncorhynchus tshawytscha*) migrating through the Sacramento - San Joaquin River Delta of California. Canadian Journal of Fisheries and Aquatic Sciences 52:855-863.

Baldwin, DH, Sandahl, JF, Labenia, JS, Scholz, NL. 2003. Sublethal effects of copper on coho salmon: impacts on nonoverlapping receptor pathways in the peripheral olfactory nervous system. Environmental Toxicology and Chemistry 22:123-131.

Ballard, WW. 1973. Normal embryonic stages for salmonid fishes, based on *Salmo gairdneri* Richardson and *Salvelinus fontinalis* (Mitchell). Journal of Experimental Zoology 184:7-26.

Baltz, DM, Vondracek, B, Brown, LR, Moyle, PB. 1987. Influence of temperature on microhabitat choice by fishes in a California stream. Trends in Ecology and Evolution 116:12-20.

Baltz, DM, Vondracek, B, Brown, LR, Moyle, PB. 1991. Seasonal changes in microhabitat use by rainbow trout in a small stream. Transactions of the American Fisheries Society 120:166-176.

Bams, RA. 1969. Adaptations in sockeye salmon associated with incubation in stream gravels. In: Northcote, TG, editor. Symposium on salmon and trout in streams. H. R. MacMillian Lectures in Fisheries. Vancouver: Institute of Fisheries, University of British Columbia. p. 71-88.

Banks, M, Barton, M. 1999. Microsatellite DNA variation among Klamath River chinook salmon sampled from fall and spring runs. Bodega Marine Laboratory, Bodega Bay, California.

Banks, MA, Rashbrook, VK, Calvaetta, MJ, Dean, CA, Hedgecock, D. 2000. Analysis of microsatellite DNA resolves genetic structure and diversity of chinook salmon (*Oncorhynchus tshawytscha*) in California's Central Valley. Canadian Journal of Fisheries and Aquatic Sciences 57:915-927.

Barnett-Johnson, RC, Ramos, FC, Grimes, CB, MacFarlane, RB. In prep. Identifying the natal origin and migration history of adult salmon using Sr isotopes obtained by ablation MC-ICPMS. NMFS, Southwest Fisheries Science Center, Santa Cruz, California:

Barnett-Johnson, RRFC, Grimes, CB, MacFarlane, RB. 2005. Sr isotopes in otoliths reveal river of origin of wild adult salmon [abstract]. Program, American Fisheries Society, California-Nevada Chapter, Annual Meeting; Sacramento. p. 39.

Barnett-Johnson, R, Ramos, FC, Grimes, CB, MacFarlane, RB. 2005. Validation of Sr isotopes in otoliths by laser ablation multicollector inductively coupled plasma mass spectrometry (LA-MC-ICPMS): opening avenues in fisheries science applications. Canadian Journal of Fisheries and Aquatic Sciences 62:2425-2430:

Barnett-Johnson, R. 2004. Determining the importance of stock structure, and production sources, to population dynamics of California Chinook salmon using otoliths and geochemical signatures. eScholarship Repository, University of California Paper 010: http://repositories.edlib.org/ucmarine/ceqi/010

Barnett, TP, Pierce, DW, AchutaRao, KM, Gleckler, PJ, Santer, BD, Gregory, JM, Washington, WM. 2005. Penetration of human-induced warming into the World's oceans. Science Express www.scienceexpress.org/2 June 2005 / Page 1/ 10.1126Science.1112418

Barrowman, NJ, Myers, RA. 2000. Still more spawner-recruit curves: the hockey stick and its generalizations. Canadian Journal of Fisheries and Aquatic Sciences 57:665-676.

Bartholow, JM, Laake, JL, Stalnaker, CB, Williamson, SC. 1993. A salmonid population model with emphasis on habitat limitations. Rivers 4:265-279.

Baxter, CV, Hauer, FR. 2000. Geomorphology, hyporheic exchange, and selection of spawning habitat by bull trout (*Salvelinus confluentus*). Canadian Journal of Fisheries and Aquatic Sciences 57:1470-1481.

The Bay Institute (TBI). 1998. From the Sierra to the sea: the ecological history of the San Francisco Bay-Delta watershed. Novato, California: The Bay Institute. http://www.bay.org/sierra_to_the_sea.htm (2005)

Beacham, TD, Murray, CB. 1993. Fecundity and egg size variation in North Pacific salmon (*Oncorhynchus*). Journal of Fish Biology 42:485-508.

Beacham, TD, Withler, FC, Morley, RB. 1985. Effect of egg size on incubation time and alevin and fry size in chum salmon ( *Oncorhynchus keta*) and coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Zoology 63:847-850.

Beacham, TD. 2003. Comment on "Rapid evolution of egg size in captive salmon". Science 302:59d.

www.sciencemag.org/cgi/content/full/302/5642/59d

Beacham, TD, Murray, CB. 1990. Temperature, egg size, and development of embryos and alevins of five species of Pacific salmon: a comparative analysis. Transactions of the American Fisheries Society 119:927-949.

Beak Consultants, Inc. 1988. Smolt emigration assessment. Sacramento, CA: Beak Consultants, Inc.

Beamish, RJ, Mahnken, C. 2001. A critical size and period hypothesis to explain natural regulation of salmon abundance and the linkage to climate and climate change. Progress in Oceanography 49:423-437.

Beamish, RJ, Noakes, DJ, McFariane, GA, Klyashtorin, L, Ivanov, VV, Kursashov, V. 1999. The regime concept and natural trends in the production of Pacific salmon. Canadian Journal of Fisheries and Aquatic Sciences 56:516-526.

Beamish, RJ, Riddell, BE, Neville, C-EM, Thompson, BL, Zhang, Z. 1995. Declines in Chinook salmon catches in the Strait of Georgia in relation to shifts in the marine environment. Fisheries Oceanography 4:543-554.

Becker, CD, Neitzel, DA, Abernethy, CS. 1983. Effects of dewatering on chinook salmon redds: tolerance of four developmental stages to one-time dewatering. North American Journal of Fisheries Management 3:372-382.

Beckman, BR, Larsen, DA, Lee-Pawlak, B, Moriyama, S, Dickhoff, WW. 1998. Insulin-like growth factor-I and environmental modulation of growth during smoltification of spring chinook salmon, (*Oncorhynchus tshawytscha*) . General and Comparative Endocrinology 109:325-335.

Beckman, BR, Larsen, DA. 2005. Upstream migration of minijack (age-2) Chinook salmon in the Columbia River: behavior, abundance, distribution, and origin. Transactions of the American Fisheries Society 134:1520-1541.

Beckman, BR, Larsen, DA, Sharpe, C, Lee-Pawlak, B, Schreck, CB, Dickhoff, WW. 2000. Physiological status of naturally-reared juvenile spring chinook salmon in the Yakima River: seasonal dynamics and changes associated with smolting. Transactions of the American Fisheries Society 129:727-753.

Beechie, TJ, Liermann, M, Beamer, EM, Henderson, R. 2005. A classification of habitat types in a large river and their use by juvenile salmonids. Canadian Journal of Fisheries and Aquatic Sciences 134:717-729.

Beeman, JW, Rondorf, DW, Fler, JC, Free, ME, Haner, PV, Sauter, ST, Venditti, DA. 1991. Assessment of smolt condition for travel time analysis. Portland, Oregon: Bonneville Power Administration. Annual Report 1990 (Contract DE-A179-8-87BP-35245).

Beer, WN. 1999. Comparison of mechanistic and empirical methods for modeling embryo and alevin development in chinook salmon. North American Journal of Aquaculture 61:126-134.

Beer, WN, Anderson, JJ. 1997. Modeling the growth of salmonid embryos. Journal of Theoretical Biology 189:297-306.

Begg, GA, Friedland, KD, Pearce, JB. 1999. Stock identification and its role in stock assessment and fisheries management: an overview. Fisheries Research 43:1-8.

Ben-David, M, Hanley, TA, Schell, DM. 1998. Fertilization of riparian vegetation by spawning Pacific salmon: the role of flooding and predator activity. Oikos 83:47-55.

Berejikian, BA, Fairgrieve, WT, Swanson, P, Tezak, EP. 2003. Current velocity and injection of GnRHa affect reproductive behavior and body composition of captively reared offspring of wild chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 60:690-699.

Berejikian, BA, Smith, RJF, Tezak, EP, Schroder, SL, Knudsen, CM. 1999. Chemical alarm signals and complex hatchery rearing habitats affect antipredatory behavior and survival of chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 56:830-838.

Berejikian, BA, Tezak, EP, LaRue, AL. 2000a. Female mate choice and spawning behavior of chinook salmon under experimental conditions. Journal of Fish Biology 57:647-661.

Berejikian, BA, Tezak, EP, Flagg, TA, LaRae, AL, Kummerow, E, Mahnken, CVW. 2000b. Social dominance, growth, and habitat use of age-0 steelhead (*Oncorhynchus mykiss*) grown in enriched and conventional hatchery rearing environments. Canadian Journal of Fisheries and Aquatic Sciences 57:628-636.

Bigler, BS, Welch, DW, Helle, JH. 1996. A review of size trends among North Pacific salmon (*Oncorhynchus* spp.). Canadian Journal of Fisheries and Aquatic Sciences 53:455-465.

Bilby, RE, Fransen, BR, Bisson, PA. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173.

Bilby, RE, Fransen, BR, Bisson, PA, Walter, JK. 1998. Response of juvenile coho salmon (Oncorhynchus kisutch) and steelhead (Oncorhynchus mykiss) to the addition of salmon carcasses to two streams in southwestern Washington, USA. Canadian Journal of Fisheries and Aquatic Sciences 55:1909-1918.

Bilby, RE, Bisson, PA. 1998. Function and distribution of large woody debris. In: Naiman, RJ, Bilby, RE, editors. River ecology and management. New York: Springer. p. 324-346.

Bisson, PA, Bilby, RE, Bryant, MD. 1987. In: Cundy, T, Salo, EO, editors. Proceedings of a symposium: streamside management-forestry and fisheries interactions; University of Washington. p. 143-190.

Bjorkstedt. Eric P. 2005. DARR 2.0: updated software for estimating abundance from stratified mark-recapture data. NOAA Technical Memorandum, NMFS-SWFSC-368.

Bjorn, TC. 1969. Embryo survival and emergence studies. Idaho Department of Fish and Game. Salmon and steelhead investigations, Project F-49-R-7.

Black, M. 1994. Recounting a century of failed fishery policy toward California's Sacramento River salmon and steelhead. Conservation Biology 8:892-894.

Black, M. 2001. Shasta salmon salvage efforts: Coleman National Fish Hatchery on Battle Creek, 1895-1992. In: Brown. Randall L., editor. Contributions to the biology of Central Valley salmonids. Fish Bulletin. California Department of Fish and Game.

Blackwell, BG, Brown, ML, Willis, DW. 2000. Relative weight ($W_r$) status and current use in fisheries assessment and management. Reviews in Fisheries Science 8:1-44.

Bograd, SJ, Checkley, DA Jr, Wooster, WS. 2003. CalCOFI: a half century of physical, chemical, and biological research in the California Current System. Deep-Sea Research II 50:2349-2353.

Boles, GL, Turek, SM, C. D. Maxwell, D. M. McGill. 1988. Water temperature effects on Chinook salmon (*Oncorhynchus tshawytscha*) with emphasis on the Sacramento River. Red Bluff, California: California Department of Water Resources, Northern District.

Booke, HE. 1999. The stock concept revisited: perspectives on its history in fisheries. Fishery Bulletin 43:9-11.

Botkin, DB, D. L. Peterson, Calhoun, JM. 2000. The scientific basis for validation monitoring of salmon for conservation and restoration plans . Forks, Washington: University of Washington, Olympic Natural Resources Center. Olympic Natural Resources Technical Report.

Botsford, LW, Lawrence, CA. 2002. Patterns of co-variability among California Current Chinook salmon, coho salmon, Dungeness crab, and physical oceanographic conditions. Progress in Oceanography 53:283-305.

Botsford, LW, Lawrence, CA, Hill, MF. 2005. Differences in dynamic response of California Current salmon species to changes in ocean habitat. Deep-Sea Research II 52:331-345.

Botsford, LW, Brittnacher, JG. 98. Viability of Sacramento River winter-run chinook salmon.

Bottom, DL. 2002. Historic habitat opportunities and food-web linkages of juvenile salmon in the Columbia River estuary and their implications for managing river flows and restoring estuarine habitat. Proposal to Bonneville Power Administration. NMFS.

Bottom, DL. 1997. To till the water: a history of ideas in fish conservation. In: Stouder, DJ, Bisson, PA, Naiman, RJ, Editors. New York: Chapman & Hall.

Bottom, DL, Simenstad, CA, Baptista, AM, Jay, DA, Burke, J, Jones, KK, Casillas, E, Schiewe, MH. 2005. Salmon at River's End: the role of the estuary in the decline and recovery of Columbia River salmon . Seattle: National Marine Fisheries Service.

Boulton, AJ. 2000. The subsurface macrofauna. In: Jones, JB, Mulholland, PJ, editors. Streams and ground waters. San Diego, CA: Academic Press. p. 337-362.

Boulton, AJ, Findlay, S, Marmonier, P, Stanley, EH, Valett, HM. 1998. The functional significance of the hyporheic zone in streams and rivers. Annual Review of Ecology and Systematics 29:59-81.

Bovee, KD. 1978. Probability of use criteria for the family Salmonidae. United States Fish and Wildlife Service. Instream Flow Information Paper 4. FWS/OBS-78/07.

Bovee, KD, Lamb, BL, Bartholow, JM, Stalnaker, CB, Taylor, J, Henriksen, J. 1998. Instream habitat analysis using the instream flow incremental methodology. U. S. Geological Survey. Biological Resources Division Information and Technology Report.

Box, GEP. 1979. Robustness in the strategy of scientific model building. In: Launer, RL, Wilkinson, GN,

Robustness in Statistics
. New York: Academic Press.

Brabrand, A, Koestler, AG, Borgstrom, R. 2002. Lake spawning brown trout related to groundwater influx. Journal of Fish Biology 60:751-763.

Bradford, JJ, Geen, GH. 1987. Size and growth of juvenile Chinook salmon back-calculated from otolith growth increments. In: Summerfelt, RC, Hall, GE, editors. The age and growth of fish. Ames, Iowa: Iowa State University Press . p. 453-461.

Bradford, MJ. 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences 52:1327-1338.

Bradford, MJ, Higgins, PS. 2001. Habitat-, season-, and size specific variation in diel activity patterns of juvenile chinook salmon (*Oncorhynchus tshawystcha*) and steelhead trout (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 58:365-374.

Bradford, MJ, Korman, J, Higgins, PS. 2005. Using confidence intervals to estimate the response of salmon populations (*Oncorhynchus spp.*) to experimental habitat alterations. Canadian Journal of Fisheries and Aquatic Sciences 62:2716-2726:

Brandes, PL, McLain, JS. 2001. Juvenile chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin estuary. In: Brown, RL, editor. Contributions to the biology of Central Valley salmonids, Vol 2. Fish Bulletin No. 179. Sacramento: California Department of Fish and Game. p. 39-138.

Brannon, EO, Amend, DF, Cronin, MA, Lannan, JE, LaPatra, S, McNeil, WJ, Noble, RE, Smith, CE, Talbot, AJ, Wedenmyer, GA, Westers, H. 2004. The controversy about hatcheries. Fisheries 29:12-31.

Brenden, TO, Murphy, BR, Birch, JB. 2003. Statistical properties of the relative weight ($W_r$) index and an alternative procedure for testing $W_r$ differences between groups. North American Journal of Fisheries Management 23:1136-1151.

Brett, JR. 1995. Energetics. In: Groot, C, Margolis, L, Clarke, WC, editors. Physiological ecology of Pacific salmon. Vancouver: UBC Press. p. 1-68.

Brett, JR, Clarke, WC, Shelbourn, JE. 1982. Experiments on thermal requirements for growth and food conversion efficiency of juvenile chinook salmon. Nanaimo, British Columbia: Department of Fisheries and Oceans. Canadian Technical Report of Fisheries and Aquatic Sciences .

Brett, JR, Shelbourn, JE, Shoop, CT. 1969. Growth rate and body composition of fingerling sockeye salmon, *Oncorhynchus nerka*, in relation to temperature and ration size. Journal of the Fisheries Research Board of Canada 26:2363-2394.

Brewer, WH. 1966. Up and down California in 1860-1864. Farquhar, Francis P., Editor. University of California Press.

Briggs, JC. 1953. The behavior and reproduction of salmonid fishes in a small coastal stream. Fish Bulletin No. 94. Sacramento, California: California Department of Fish and Game.

Broad, RD, Gangmark, HA. 1956. Establishment of a controlled-flow area and construction of king salmon spawning pens at Mill Creek, California. Progressive Fish Culturist 18:131-134.

Brodeur, RD, Boehlert, GW, Casillas, E, Eldridge, MB, Helle, JH, Peterson, WT, Heard, WR, Lindley, ST, Schiewe, MH. 2000. A coordinated research plan for estuarine and ocean research on Pacific salmon. Fisheries 25:716.

Brodeur, RD, Myers, KW, Helle, JH. 2003. Research conducted by the United States on the early ocean life history of Pacific salmon. North Pacific Anadromous Fish Commission Bulletin 3:89-131.

Brodeur, RD, Fisher, JP, Teel, DJ, Emmett, RE, Casillas, E, Miller, TW. 2004. Juvenile salmonid distribution, growth, condition, origin, and environmental and species associations in the Northern California Current. Fishery Bulletin 10:25-46.

Brown, LR. 2003. Will tidal wetland restoration enhance populations of native fishes. San Francisco Estuary and Watershed Science (online serial) 1:Article 2. http://repositories.cdlib.org/jmie/sfews.vol1/iss1/aart2

Brown, LR, Ford, T. 2001. Distribution and abundance of Chinook salmon and resident fishes of the lower Tuolumne River, California. In: Brown, RL, editor. Contributions to the biology of Central Valley salmonids, Fish Bulletin No. 179. 2. p. 253-304.

Brown, LR, Ford, T. 2002. Effects of flow on the fish communities of a regulated California River: implications for managing native fishes. Regulated Rivers: Research and Management 18:331-342.

Brown, LR, Moyle, PB. 1991. Changes in habitat and microhabitat partitioning within an assemblage of stream fishes in response to predation by Sacramento squawfish (*Ptycholcheilus grandis*). Canadian Journal of Fisheries and Aquatic Sciences 48:849-856.

Brown, LR, Moyle, PB. 1981. The impact of squawfish on salmonid populations: a review. North American Journal of Fisheries Management 1:104-111.

Brown, R, Cavallo, B, Jones, K. 2004. The effects of the Feather River Hatchery on naturally spawning salmonids. California Department of Water Resources.

Brown, R, Greene, S. 1992. Biological assessment: effects of Central Valley Project and State Water Project Delta operations on winter-run Chinook salmon. Sacramento, California: California Department of Water Resources.

Brown, R, Kimmerer, W. 2002. Chinook salmon and the Environmental Water Account: a summary of the 2002 salmonid workshop. Sacramento, California: CALFED Science Program.

Brown, R, Kimmerer, W. 2001. Summary report of the June 21, 2001 salmonid workshop for the CALFED Environmental Water Account. Sacramento, California:

Brunke, M, Gonser, T. 1997. The ecological significance of exchange processes between rivers and groundwater. Freshwater Biology 37:1-33.

Buckley, LJ, Caldarone, E, Ong, TL. 1999. RNA-DNA ratio and other nucleic acid-based indicators for growth and condition in marine fishes. Hydrobiologia 401:265-277.

Buer, K. 1985. Sacramento River spawning gravel studies. Red Bluff, California: California Department of Water Resources, Northern District.

Buffington, JM, Montgomery, DR, Greenberg, HM. 2004. Basin-scale availability of salmonid spawning gravel as influenced by channel type and hydraulic roughness characteristics. Canadian Journal of Fisheries and Aquatic Sciences 61:2085-2096.

Bult, TP, Haedrich, RL, Schneider, DC. 1998. New technique describing spatial scaling and habitat selection in riverine habitats. Regulated Rivers: Research and Management 14:107-118.

Bult, TP, Riley, SC, Haedrich, RL, Gibson, RJ, Heggenes, J. 1999. Density-dependent habitat selection by juvenile Atlantic salmon (*Salmo salar*) in experimental riverine habitats. Canadian Journal of Fisheries and Aquatic Sciences 56:1298-1306.

Burgner, RL. 1991. Life history of sockeye salmon (*Oncorhynchus nerka*). In: Groot, C, Margolis, L, editors. Pacific salmon life histories. Vancouver: UBC Press. p. 1-118.

Burner, CJ. 1951. Characteristics of spawning nests of Columbia River salmon. Fishery Bulletin 52:97-110.

Burnham, KP, Anderson, DR. 1998. Model selection and inference: a practical information-theoretic approach. New York: Springer.

Burns, DC. 1974. Feeding by mature steelhead (*Salmo gairdnerii gairdnerii*) in the spawning stream. California Fish and Game 60:

Busack, C, Hankin, D, Hedrick, RP, Lichatowich, JA, Reisenbichler, R. 2004. Compatibility of Coleman National Fish Hatchery operations and restoration of anadromous salmonids in Battle Creek. Report of Technical Review Panel. Sacramento, California: CALFED Bay-Delta Program.

Busack, CA, Currens, KP. 1995. Genetic risks and hazards in hatchery operations . In: Schramm, HLJ, Piper, RG, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium 15.American Fisheries Society. p. 71-80.

Busacker, GP, Adelman, IR, Goolish, EM. 1990. Growth. In: Schreck, CB, Moyle, PB , Editors. Methods for fish biology. Bethesda, Maryland: American Fisheries Society. p. 363-388.

CALFED Bay-Delta Program. 2005. 10-year action plan framework, final draft. Sacramento, California: CALFED Bay-Delta Program. http://calwater.ca.gov/Revitalizing_CALFED/Revitalizing_Calfed.shtml

CALFED Bay Delta Program. 2005. Environmental Water Account Final EIS/EIR. Sacramento, California: http://calwater.ca.gov/Programs/EnvironmentalWaterAccount/EnvironmentalWaterAccount.shtml

California Department of Fish and Game (CDFG). 2004b. Sacramento River spring-run Chinook salmon: 2003-2004 biennial report. Sacramento, California: California Department of Fish and Game, Native Anadromous Fish and Watershed Branch.

California Department of Fish and Game (CDFG). 2001. Evaluation of effects of flow fluctuations on the

anadromous fish populations in the Lower American River. Sacramento: California Department of Fish and Game. Stream Evaluation Program Technical Report.

California Department of Fish and Game (CDFG). 2004a. Sacramento River winter-run Chinook salmon: biennial report 2003-2003. Sacramento, California: California Department of Fish and Game, Native Anadromous Fish and Watershed Branch.

California Department of Fish and Game (CDFG). 1998. A status review of the spring-run Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento River drainage. Sacramento, California: Candidate Species Status Report 98-01.

California Little Hoover Commission. 2005. Still imperiled, still important: the Little Hoover Commission review of the CALFED Bay Delta Program. Sacramento, California: Little Hoover Commission of California. http://www.lhc.gov/hcdir/report183.html

Campana, SE. 1983. Feeding periodicity and the production of daily growth increments in otoliths of steelhead trout (*Salmo gairdneri*) and starry flounder (*Platichthys stellatus*). Canadian Journal of Zoology 61:15912-1597.

Campbell, EA. 1998. Influence of streamflow and predators on habitat choice by trout [dissertation]. University of California, Davis.

Campbell, RF, Neuner, JH. 1985. Seasonal and diurnal shifts in habitat utilized by resident rainbow trout in western Washington Cascade Mountain streams. In: Olsen, FW, White, RG, Hamre, RH, Editors. Symposium on small hydropower and fisheries; Bethesda, Maryland: American Fisheries Society.

Campton, DE. 1995. Genetic effects of hatchery fish on wild populations of Pacific salmon and steelhead: what do we really know. In: Schramm, HL Jr, Piper, RG, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium 15. p. 337-353.

Candy, JR, Beacham, TD. 2000. Patterns of homing and straying in southern British Columbia coded-wire tagged Chinook salmon (*Oncorhynchus tshawytscha*) populations. Fisheries Research 47:41-56.

Candy, JR, Quinn, TP. 1999. Behavior of adult Chinook salmon (*Oncorhynchus tshawytscha*) in British Columbia coastal waters determined from ultrasonic telemetry. Canadian Journal of Zoology 77:1161-1169.

Carl, LM. 1982. Natural reproduction of coho salmon and Chinook salmon in some Michigan streams. North American Journal of Fisheries Management 2:375-380.

Carl, LM, Healey, MC. 1984. Differences in enzyme frequency and body morphology among three juvenile life history types of chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 41:1070-1077.

Castleberry, DT, Cech, JJJ, Erman, DC, Hankin, D, Healey, MC, Kondolf, GM, Mangel, M, Mohr, M, Moyle, PB, Nielsen, J, Speed, TP, Williams, JG. 1996. Uncertainty and instream flow standards. Fisheries 21:20-21.

Castleberry, DT, Cech, JJ Jr, Saiki, MK, Martin, BA. 1991. Growth, condition and physiological performance of juvenile salmonids from the American River, February through June, 1991. Dixon, California: U. S. Fish and Wildlife Service.

Castleberry, DT, Cech, JJ Jr, Saiki, MK, Martin, BA. 1993. Growth, condition and physiological performance of juvenile salmonids from the American River, February through July, 1992. Dixon, California: U. S. Fish and Wildlife Service.

Castleberry, DT, Saiki, MK, Martin, BA. 1994. Field validation of daily increment formation on the sagittal otoliths of juvenile Chinook salmon. Dixon, California: U. S. Fish and Wildlife Service.

Cavallo, B, Kurth, R, Kindoff, J, Seesholtz, A, Perrone, M. 2003. Distribution and habitat use of steelhead and other fishes in the lower Feather River, 1999-2001. Sacramento, California: California Department of Water Resources.

Cech, JJ Jr, Myrick, CA. 1999. Steelhead and Chinook salmon bioenergetics: temperature, ration and genetic effects. University of California Water Resources Center, University of California, Davis.

Cederholm, CJ, Kunze, MD, Murota, T, Sibitani, A. 1999. Pacific salmon carcasses: essential contributions of nutrients and energy for aquatic and terrestrial ecosystems. Fisheries 24:6-15.

Centers for Water and Wildland Resources (CWWR). 1999. Tuolumne River technical advisory committee peer review forum for methodologies of measuring salmon smolt survival, University of California, Davis, December 18, 1998. Davis, California: Centers for Water and Wildland Resources, University of California,

Davis .

Chapman, DW. 1966. Food and space as regulators of salmonid populations in streams. The American Naturalist 100:345-357.

Chapman, DW, Bjornn, TC. 1969. Distribution of salmonids in streams, with special reference to food and feeding. In: Northcote, TG, editor. Symposium on salmon and trout in streams; Vancouver: UBC Press. p. 153-176. H. R. MacMillian Lectures in Fisheries.

Chapman, DW. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117:1-21.

Chapman, WM. 1943. The spawning of Chinook salmon in the main Columbia River. Copeia 3:168-170.

Chavez, FP, Pennington, JT, Castro, CG, Ryan, JP, Michisaki, RP, Schlining. B., Walz. P., Buck, KR, McFadyen, A, Collings, CA. 2002. Biological and chemical consequences of the 1997-1998 El Niño in central California waters. Progress in Oceanography 44:205-232.

Chilcote, MW. 2003. Relationship between natural productivity and the frequency of wild fish in mixed spawning populations of wild and hatchery steelhead (*Oncorhynchus mykiss*). Canadian Journal of Fisheries and Aquatic Sciences 60:1057-1067.

Chin, JL, Graymer, RW. 2001. Regional setting of the Gulf of the Farallones. In: Karl, HA, Chin, JL, Ueber, E, Stuaffer, PH, Hendley, JWI, editors. Beyond the Golden Gate -- Oceanography, geology, biology, and environmental issues in the Gulf of the Farallones. USGS Circular 1198.

Clark, GH. 1929. Sacramento River salmon fishery. California Fish and Game 15:1-11.

Clark, GH. 1928. Sacramento- San Joaquin salmon (*Oncorhynchus tshawytscha*) fishery of California. Fish Bulletin 17:1-73.

Clark, GH. 1943. Salmon at Friant Dam -- 1942. California Fish and Game 29:89-91.

Clarke, WC, Whithler, RE, Shelbourn, JE. 1992. Genetic control of juvenile life history pattern in chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 49:2300-2306.

Clarke, WC, Hirano, T. 1995. Osmoregulation. In: Groot, C, Margolis, L, Clarke, WC, editors. Physiological ecology of Pacific salmon. Vancouver, British Columbia: UBC Press. p. 317-438.

Clarke, WC, Withler, RE, Shelborn, JE. 1994. Inheritance of smolting phenotypes in backcrosses of hybrid stream-type X ocean-type chinook salmon (*Oncorhynchus tshawytscha*). Estuaries 17:13-25.

Clausen, J, Keck, DD, Hiesey, WM. 1958. Experimental studies on the nature of species. I. Effect of varied environments on Western North American plants. Washington, D. C.: Carnegie Institution of Washington.

Cleveland, WS. 1985. The elements of graphing style. Monterey, CA: Wadsworth Books.

Collins, BD, Montgomery, DR. 2002. Forest development, wood jams, and restoration of floodplain rivers in the Puget Lowland, Washington. Restoration Ecology 10:237-247.

Collins, BD, Montgomery, DR, Haas, AD. 2002. Historical changes in the distribution and function of large wood in Puget Lowland rivers. Canadian Journal of Fisheries and Aquatic Sciences 59:66-76.

Collins, CA, Pennington, JT, Castro, CG, Rago, TA, Chavez, FP. 2003. The California Current system of Monterey, California: physical and biological coupling. Deep-Sea Research II 50:2389-2404.

Combs, BD. 1965. Effect of temperature on the development of salmon eggs. Progressive Fish-Culturist 27:134-137.

Combs, BD, Barrows, RE. 1957. threshold temperatures for the normal development of Chinook salmon eggs. Progressive Fish-Culturist 19:3-6.

Commissioners of Fisheries of the State of California. 1886. Biennial Report for 1885-1886. Sacramento, California:

Commissioners of Fisheries of the State of California. 1875. Report for the years 1874 and 1875. Sacramento, California:

Commissioners of Fisheries of the State of California. 1877. Report for the years 1876 and 1877. Sacramento, California:

Cone, RS. 1989. The need to reconsider the use of condition indices in fishery science. Transactions of the American Fisheries Society 118:510-514.

Congleton, JL, Davis, SK, Foley, SR. 1981. Distribution, abundance and outmigration timing of chum and chinook salmon fry in the Skagit salt marsh. In: Brannon, EL, Salo, EO, editors. Salmon and trout migratory behavior symposium; Seattle, Washington: University of Washington, School of Fisheries.

Congleton, JL, Wagner, T, Evavoid, J, Hafner, J, Fryer, D, Sun, B. 2004. Evaluation of physiological differences in transported, in-river migrating, and multiple-bypassed juvenile salmon (DACW68-00-C-0031), Annual Report, 2002. Walla Walla, Washington: Dept. of Fish and Wildlife Resources, University of Idaho.

Connor, WP, Sneva, JG, Tiffan, KF, Steinhorst, RK, Ross, D. 2005. Two alternative juvenile life history types for fall Chinook salmon in the Snake River basin. Transactions of the American Fisheries Society 134:291-304.

Conomos, TJ. 1979. San Francisco Bay, the urbanized estuary. San Francisco, California: American Association for the Advancement of Science.

Conover, DO, Munch, SB. 2002. Sustaining fisheries yields over evolutionary time scales. Science 297:94-96.

Conover, WP, Burge, HL. 2003. Growth of wild subyearling fall Chinook salmon in the Snake River. North American Journal of Fisheries Management 23:594-599.

Cooke, SJ, Hinch, SG, Farrell, AP, Lapointe, MF, Jones, SRM, Macdonald, JS, Patterson, DA, Healey, MC, Van Der Kraak, G. 2004. Abnormal migration timing and high en route mortality of sockeye salmon in the Fraser River, British Columbia. Fisheries 29:22-33.

Cooney, RT, Brodeur, RD. 1998. Carrying capacity and North Pacific salmon production: stock-enhancement implications. Bulletin of Marine Science 6:443-464.

Cooper, AB, Mangel, M. 1999. The dangers of ignoring metapopulation structure for the conservation of salmonids. Fishery Bulletin 97:213-226.

Cope, PB, Staler, DW. 1957. Role of Coleman Hatchery in maintaining a king salmon run. United State Fish and Wildlife Service. Research Report 47.

Cordone, AJ, Kelly, DW. 1961. The influence of inorganic sediment on the aquatic life of streams. California Fish and Game 47:189-228.

Cramer, FK, Hammack, DF. 1952. Salmon Research at Deer Creek, California. Washington, D. C.: U.S. Fish and Wildlife Service. Special Scientific Report.

Cramer, SP. 1991. Contribution of Sacramento Basin hatcheries to ocean catch and river escapement of fall Chinook salmon. Corvallis, Oregon: S. P. Cramer & Associates.

Cramer, SP, Daigeault, M, Teply, M. 2003. Conceptual framework for an integrated life cycle model of winter-run Chinook salmon in the Sacramento River. Gresham, Oregon: S. P. Cramer & Associates. http://www.spcramer.com/imf.htm

Cramer, SP, Lichatowich, JA. 1978. Factors influencing the rate of downstream migration of juvenile Chinook salmon in the Rogue River. In: Shepard, BC, Ginetz, RMJ, Compilers. Proceedings of the 1977 Northwest Pacific Chinook and Coho Salmon Workshop; Fish. Mar. Serv. (Can). p. 43-48. Technical Report 759.

Cramer, SP, Alley, D, Baldridge, J, Bernard, K, Demko, D, Dettman, D, Farrell, B, Hagar, J, Laird, A, Mitchell, B, Orton, R, Taylor, T, Van Dyke, E. 1994. The status of steelhead populations in California in regards to the Endangered Species Act. Gresham, Oregon: S.P. Cramer & Associates.

Cramer, SP, Demko, DB. 1986. The status of late-fall and spring Chinook salmon in the Sacramento River Basin regarding the Endangered Species Act. Gresham. Oregon: S. P. Cramer & Associates.

Crisp, DT. 1981. A desk study of the relationship between temperature and hatching time for the eggs of five species of salmonid fishes. Freshwater Biology 11:361-368.

Crisp, DT. 1988. Prediction, from temperature, of eyeing, hatching, and 'swim-up' times for salmonid embryos. Freshwater Biology 19:41-48.

Crisp, DT, Carling, PA. 1989. Observations on siting, dimensions and structure of salmonid redds. Journal of Fish Biology 34:119-134.

Cuenco, ML. 1994. A model of an internally supplemented population. Transactions of the American Fisheries Society 123:277-288.

Curry, RA, Gehrels, J, Noakes, DLG, Swainson, R. 1994. Effects of river flow fluctuations on groundwater discharge through brook trout, *Salvelinus fontinalis*, spawning and incubation habitats. Hydrobiologia 227:121-134.

Daley, WJ. 1993. The use of fish hatcheries: polarizing the issue. Fisheries 18 (3):4-5.

Damsgard, B, Dill, LM. 1998. Risk-taking behavior in weight-compensating coho salmon, *Oncorhynchus kisutch.* Behavioral Ecology 9:26-32.

Dauble, DD, Watson, DG. 1997. Status of fall chinook salmon populations in the mid-Columbia River 1948-1992. North American Journal of Fisheries Management 17:283-300.

Dayton, PK. 1998. Reversal of the burden of proof in fisheries. Science 279:821-822.

Deas, ML, Lowney, CL. 2000. Water temperature modeling review. http://www.cwemf.org/Pubs/TempReview.pdf: Bay-Delta Modeling Forum. www.cwemf.org/Pubs/BDMFTemp.Review.pfd

Deas, ML, Meyer, GK, Lowney, CL, Orlob, GT, King, IP. 1997. Sacramento River Temperature Modeling Project. Department of Civil and Environmental Engineering, University of California, Davis.

Dedual, M. 2004. Case study: the Tongariro River. Workshop on IFIM in New Zealand; Nelson, New Zealand. http://www.doc.govt.nz/Explore/hunting-and-fishing/Taupo-Fishery/PDF/IFIM%20PDFs/Tongariro-River-Case-Study.pdf

Dedual, M. 2003. Sonoma Creek: where it all began for New Zealand rainbow trout. Target Taupo 44:54-55.

del Rosario, RB, Ruch, VH. 2000. Invertebrates in intermittent and perennial streams: is the hyporheic zone a refuge from drying? Journal of the North American Benthological Society 19:680-696.

Delisle, G. 1966. Preliminary fish and wildlife plan for San Francisco Bay-Estuary. Prepared for the San Francisco Bay Conservation and Development Commission. California Department of Fish and Game.

Demko, DB, Cramer, SP. 1996. Effects of pulse flows on juvenile Chinook migration in the Stanislaus River. Gresham, Oregon: S. P. Cramer & Associates.

Dempson, JB, Stansbury, DE. 1991. Using partial counting fences and a two-sample stratified design for mark-recapture estimation of an Atlantic salmon smolt population. North American Journal of Fisheries Management 11:27-37.

Deriso, RB. 1980. Harvesting strategies and parameter estimate for an age structured model. Canadian Journal of Fisheries and Aquatic Sciences 37:268-282.

Dettinger, MD. 2005. From climate-change spaghetti to climate-change distributions for 21st Century California. San Francisco Estuary and Watershed Science 3:Issue 1, Article 4. http.//repositories.edlib.org/jmie/sfews/vol3/iss1/art4

Dettinger, MD, Cayan, DR, Meyer, MK, Jeton, AE. 2004. Simulated hydrologic responses to climate variations and change in the Merced, Carson, and American river basins. Sierra Nevada, California, 1900-2099. Climate Change 62:283-317.

Dettman, DH, Kelley, DW. 1986. Assessment of the Carmel River steelhead resource. Volume I. Biological Investigations. Newcastle, California: D. W. Kelley & Associates.

Dettman, DH, Kelley, DW. 1987. The roles of Feather and Nimbus salmon and steelhead hatcheries and natural reproduction in supporting fall run chinook salmon populations in the Sacramento River basin. Newcastle, California: D. W. Kelley & Associates.

Dettman, DH, Kelley, DW, Mitchell, WT. 1987. The influence of flow on Central Valley salmon. Newcastle, California: D. W. Kelley & Associates.

DeVries, P. 1997. Riverine salmonid egg burial depths: a review of published data and implications for scour studies. Canadian Journal of Fisheries and Aquatic Sciences 54:1685-1698.

DeVries, P, Goetz, F, Fresh, K, Sheiler, D. 2004. Evidence of a lunar gravitation cue on timing of estuarine entry by Pacific salmon smolts. Transactions of the American Fisheries Society 133:1379-1395.

Dill, LM. 1969. The sub-gravel behaviour of Pacific salmon larvae. In: Northcote, TG, editor. Symposium on salmon and trout in streams. H. R. MacMillian Lectures in Fisheries. University of British Columbia. p. 89-99.

Dill, PA. 1981. Behavior of alevin influencing distribution in gravel. In: Brannon, EL, Salo, EO, editors. Salmon and trout migratory behavior symposium; Seattle, Washington: University of Washington, School of Fisheries. p. 61-70.

Dittman, AH, Quinn, TP. 1996. Homing in Pacific salmon: mechanisms and ecological basis. Journal of Experimental Biology 199:83-91.

Dobzhansky, T. 1973. Nothing in biology makes sense except in light of evolution. The American Biology Teacher 35:125-129.

Dolloff, A, Kershner, J, Thurow, R. 1996. Underwater observation. In: Murphy, BR, Willis, DW, editors. Fisheries Techniques. Bethesda, Maryland: American Fisheries Society. p. 533-554.

Duff, JH, Triska, FJ. 2000. Nitrogen biogeochemistry and surface-subsurface exchange in streams. In: Jones, JB, Mulholland, PJ, editors. Streams and ground waters. San Diego, CA: Academic Press. p. 197-220.

Dunning, HC. in press. California instream flow protection law: then and now. McGeorge Law Review

EA Engineering, Science, and Technology. 1991a. Lower Tuolumne River 1990 Predation Study, Interim Report. Lafayette, California: EA Engineering, Science, and Technology. Unpublished report to the Turlock Irrigation District and Modesto Irrigation District.

EA Engineering, Science and Technology. 1991e. Lower Tuolumne River Chinook salmon redd excavation report. Unpublished report to the Turlock Irrigation District and Modesto Irrigation District.

EA Engineering, Science and Technology. 1991b. Lower Tuolumne River Chinook salmon redd excavations interim report. Unpublished report to the Turlock Irrigation District and Modesto Irrigation District.

EA Engineering, Science and Technology. 1991c. Lower Tuolumne River spawning gravel availability and superimposition report. Unpublished report to the Turlock Irrigation District and Modesto Irrigation District.

EA Engineering, Science and Technology. 1991d. Lower Tuolumne River spawning gravel studies interim report. Unpublished report to the Turlock Irrigation District and Modesto Irrigation District.

EA Engineering, Science and Technology. 1991f. San Joaquin River system Chinook salmon population model documentation.

Ebersole, JL, Liss, WJ, Frissell, C. 2001. Relationship between stream temperature, thermal refugia and rainbow trout *Oncorhynchus mykiss* abundance in arid-land streams in the northwestern United States.

Efron, B, Tibshirani, R. 1993. An introduction to the bootstrap. New York: Chapman & Hall.

Efron, B, Tibshirani, R. 1991. Statistical data analysis in the computer age. Science 252:390-395.

Einum, S, Fleming, IA. 2002. Does within-population variation in fish egg size reflect maternal influences on optimal values. The American Naturalist 160:756-765.

Einum, S, Fleming, IA. 2000. Highly fecund mothers sacrifice offspring survival to maximize fitness. Nature 405:565-567.

Einum, S, Fleming, IA. 2001. Implications of stocking: ecological interactions between wild and released salmon. Nordic Journal of Freshwater Resources 75:56-70.

Einum, S, Fleming, IA. 1999. Maternal effects of egg size in brown trout (*Salmo trutta*): norms of reaction to environmental quality. Proceedings of the Royal Society of London, Series B 266:2095-2100.

Einum, S, Flemming, IA. 2000. Selection against late emergence and small offspring in Atlantic salmon (*Salmo salar*). Evolution 54:628-639.

Einum, S, Hendry, AP, Fleming, IA. 2002. Egg-size evolution in aquatic environments: does oxygen availability constrain size? Proceedings of the Royal Society of London, Series B 269:2325-2330.

Einum, S, Kinnison, MT, Hendry, AP. 2004. Evolution of egg size and number. In: Hendry, AP, Stearns, SC, editors. Evolution illuminated: salmon and their relatives. Oxford University Press. p. 126-153.

Elena, SF, Sanjuán, R. 2003. Climb every mountain? Science 302:2074-2075.

Elliott, JM. 1985. The choice of a stock-recruitment model for migratory trout, *Salmo trutta*, in a Lake District stream, 1966-83. Archiv für Hydrobiologie 104:145-168.

Elliott, JM. 1976. The energetics of feeding, metabolism and growth of brown trout (*Salmo trutta* L.) in relation to body weight, water temperature, and ration size. Journal of Animal Ecology 45:923-948.

Elliott, JM. 1975. The growth rate of brown trout (*Salmo trutta* L.) fed on maximum rations. Journal of Animal Ecology 44:805-821.

Elliott, JM. 1994. Quantitative ecology and the brown trout. Oxford Series in Ecology and Evolution. Oxford University Press.

Elliott, JM. 2002. Shadow competition in wild juvenile sea-trout. Journal of Fish Biology 61:1268-1281.

Elliott, JM, Hurley, MA, Fryer, RJ. 1995. A new, improved growth model for brown trout, *Salmo trutta*.

Functional Ecology 9:290-298.

Elwood, JW, Newbold, RV, O'Neil, RV, Van Winkle, W. 1983. Resource spiraling: an operational paradigm for analyzing lotic systems. In: Fontainne, TD, Bartell, SM, editors. Dynamics of Lotic Ecosystems. Ann Arbor, MI: Ann Arbor Science (Butterworth). p. 3-27.

Emlen, JM. 1991. Heterosis and outbreeding drepression: a multi-locus model and an application to a salmon population. Fisheries Research 12:187-212.

EPRI. 2000. Instream flow assessment methods: guidance for evaluating instream flow needs in hydropower licensing. Palo Alto, CA: Electric Power Research Institute.

Erande, B, Dieckmann, U, Heino, M. 2004. Adaptive changes in harvested populations: plasticity and evolution of age and size at maturity. Proceedings of the Royal Society of London, Series B 271:425-423.

Erkinaro, J, Shchurov, IL, Saari, T, Niemela, E. 1994. Occurrence of Atlantic salmon parr in redds at spawning time. Journal of Fish Biology 45:899-900.

Erkkila, LF, Moffett, JW, Cope, OB, Smith, BR, Nielson, RS. 1950. Sacramento - San Joaquin Delta Fishery Resources: Effects of Tracy Pumping Plant and Delta Cross Channel. Sacramento, California: U.S. Fish and Wildlife Service. Special Scientific Report: Fisheries No. 56.

Everest, FH, Chapman, DW. 1972. Habitat selection and spatial interaction by juvenile Chinook salmon and steelhead trout in two Idaho streams. Journal of the Fisheries Research Board of Canada 29:91-100.

Ewing, RD, Ewing, GS, Satterthwaite, TD. 2001. Changes in gill $Na^+$, $K^+$ -ATPase specific activity during seaward migration of wild juvenile chinook salmon. Journal of Fish Biology 58:1414-1426.

Ewing, RD, Fustish, CA, Johnson, SL, Pribble, HJ. 1980. Seaward migration of juvenile chinook salmon without elevated gill (Na+K+)-ATPase activities. Transactions of the American Fisheries Society 109:349-356.

Ewing, RD, Sheaham, JE, Lewis, MA, Palmisano, AN. 1998. Effects of rearing density and raceway conformation on growth, food conversion, and survival of juvenile spring Chinook salmon. Progressive Fish-Culturist 60:167-178.

Fausch, KD. 1993. Experimental analysis of microhabitat selection by juvenile steelhead (*Oncorhynchus mykiss*) and coho salmon (*O. kisutch*) in a British Columbia stream. Canadian Journal of Fisheries and Aquatic Sciences 50:1198-1207.

Fausch, KD. 1984. Profitable stream positions for salmonids: relating specific growth rate to net energy gain. Canadian Journal of Zoology 62:441-451.

Fausch, KD, Torgersen, CE, Baxter, CV, Li, HW. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. BioScience 52:483-496s.

Feige, U, Morimoto, RI, Yahara, I, Polla, BS . 1996. Stress-inducible cellular responses. Bassel, Switzerland: Birkhauser Verlag.

Felsenstein, J. 1997. Population differentiation and evolutionary processes. In: Grant, WS, Editor. Genetic effects of straying of non-native hatchery fish into natural populations, NOAA Technical Memorandum NMFS NWFSC 30. http://www.nwfsc.noaa.gov/publications/techmemos/tm30/felsenstein.htm

Feyrer, F, Sommer, T, Harrell, W. 2006. Importance of flood dynamics versus intrinsic physical habitat in structuring fish communities: evidence from two adjacent engineered floodplains on the Sacramento River, California. North American Journal of Fisheries Management 26:408-417. DOI: 10.1577/M05-113.1

Fields, W. 1976. Food habits of juvenile king salmon in the Sacramento-San Joaquin Delta, 1975-1976. Newcastle, California: Hydrozoology.

Finney, BP, Gregory-Evans, I, Douglas, MSV, Smol, JP. 2002. Fisheries productivity in the northeastern Pacific Ocean over the past 2,200 years. Nature 416:729-723.

Finney, BP, Gregory-Evans, I, Sweetman, J, Douglas, MSV, Smol, JP. 2000. Impacts of climatic change and fishing on Pacific salmon abundance over the past 300 years. Science 290:795-799.

Fisher, FW. 1992. Chinook salmon, *Oncorhynchus tshawytscha*, growth and occurrence in the Sacramento-San Joaquin River system. California Department of Fish and Game, Inland Fisheries Division.

Fisher, FW. 1994. Past and present status of Central Valley chinook salmon . Conservation Biology 8:870-873.

Fisher, JP, Pearcy, WG. 1990. Distribution and residence times of juvenile fall and spring chinook salmon in Coos Bay, Oregon. Fishery Bulletin 88:51-58.

Five Agency Delta Salmon Team, Fish Facilities Subcommittee. 1991. Evaluation of the Feasibility of protecting downstream migrant chinook salmon smolts in the Sacramento River and San Joaquin River with physical facilities.

Flagg, TA, Berejikian, BA, Colt, JE, Dickhoff, WW, Harrell, LW, Maynard, DJ, Nash, CE, Strom, MS, Iwamoto, RN, Mahnken, CVW. 2000. Ecological and behavioral impacts of artificial production strategies on the abundance of wild salmon populations. National Marine Fisheries Service. NOAA Technical Memorandum NMFS-NWFSC-41.

Flagg, TA, Nash, CE. 1999. A conceptual framework for conservation strategies for Pacific salmonids. NOAA Technical Memorandum NMFS-NWFSC-38.

Fleming, IA. 1998. Pattern and variability in the breeding systems of Atlantic salmon (*Salmo salar*), with comparisons to other salmonids . Canadian Journal of Fisheries and Aquatic Sciences 55 (Suppl. 1):59-76.

Fleming, IA, Agustsson, T, Finstad, B, Johnsson, JI, Björnsson, BT. 2002. Effects of domestication on growth physiology and endocrinology of Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 59:1323-1330.

Fleming, IA, Einum, S, Jonnson, B, Jonnson, N. 2003. Comment on "Rapid evolution of egg size in captive salmon". Science 302:59b. www.sciencemag.org/cgi/content/full/302/5642/59b

Fleming, IA, Gross, MR. 1993. Breeding success of hatchery and wild coho salmon (*Oncorhynchus kisutch*) in competition. Ecological Applications 3:230-245.

Fleming, IA, Gross, MR. 1990. Latitudinal clines: a trade-off between egg number and size in Pacific salmon. Ecology 71:1-11.

Fleming, IA, Gross, MR. 1992. Reproductive behavior of hatchery and wild coho salmon (*Oncorhynchus kisutch*): does it differ? Aquaculture 103:101-121.

Fleming, IA, Jonnson, B, Gross, MR. 1994. Phenotypic divergence of sea-ranched, farmed, and wild salmon. Canadian Journal of Fisheries and Aquatic Sciences 51:2808-2824.

Fleming, IA, Petersson, E. 2001. The ability of released, hatchery salmonids to breed and contribute to the natural productivity of wild populations. Nordic Journal of Freshwater Resources 75:71-98.

Fleming, IA, Reynolds, JD. 2004. Salmonid breeding systems. In: Hendry, AP, Stearns, SC, Editors. Evolution illuminated, salmon and their relatives. Oxford University Press.

Foott, JS. 1990. The organosomatic analysis system: a tool for the evaluation of smolt quality. In: Hauser, TJ, editor. Proceedings of the 1990 Northwest Pacific Chinook and coho salmon workshop; Arcata, California: California Cooperative Fishery Research Unit, Humboldt State University.

Foott, JS, Walker, RL, Williamson, JD, True, KC. 1994. Anderson, California: U.S. Fish and Wildlife Service, California-Nevada Fish Health Center.

Ford, MJ. 2004. Conservation units and preserving diversity. In: Hendry, AP, Stearns, SC, editors. Evolution illuminated: salmon and their relatives. Oxford University Press. p. 338-357.

Ford, MJ. 2002. Selection in captivity during supportive breeding may reduce fitness in the wild. Conservation Biology 16:815-825.

Ford, T, Brown, LR. 2001. Distribution and abundance of Chinook salmon and resident fishes in the lower Tuolumne River, California. In: Brown, RL, Editor. Contributions to the biology of Central Valley salmonids, Fish Bulletin 179. Sacramento, CA: California Department of Fish and Game.

Fowler, RT, Scarsbrook, MR. 2002. Influence of hydrologic exchange patterns on water chemistry and hyporheic invertebrate communities in three gravel-bed rivers. New Zealand Journal of Marine and Freshwater Research 36:471-482.

Fox, CW, Heath, DD. 2003. Response to comment on "Rapid evolution of egg size in captive salmon". Science 302:59c. www.sciencemag.org/cgi/content/full/302/5642/59c

Fraley, EV, Munk, K. 1997. Incidence of thermally marked pink, chum and sockeye salmon in the coastal waters of the Gulf of Alaska. Juneau, Alaska: National Marine Fisheries Service, NOAA, Alaska Science Center.

Francis, RC, Sibley, TH. 1991. Climate change and fisheries: what are the real issues? Northwest Environmental Journal 7:295-307.

Fraser, NHC, Heggenes, J, Metcalfe, NB, Thorpe, JE. 1995. Low summer temperatures cause juvenile fish to

become nocturnal. Canadian Journal of Zoology 73:446-451.

Freedman, DA. 1999. Ecological inference and the ecological fallacy. Department of Statistics, University of California, Berkeley. Technical Report No. 549.

Freedman, DA. 1983. A note on screening regression equations. The American Statistician 37:152-155.

Fretwell, SD. 1972. Populations in a seasonal environment. Princeton, New Jersey: Princeton University Press.

Fretwell, SD, Lucas, HL. 1970. On territorial behavior and other factors influencing habitat distribution in birds. I. Theoretical development. Acta Biotheoretica 19:16-36.

Frissell, CA, Liss, WJ, Gresswell, RE, Nawa, RK, Ebersole, JL. 1997. A resource in crisis: changing the measure of salmon management. In: Stouder, DJ, Bisson, PA, Naiman, RJ, editors. Pacific salmon and their ecosystems. New York: Chapman & Hall. p. 411-446.

Fry, DH Jr. 1961. King salmon spawning stocks of the California Central Valley, 1940-1959. California Fish and Game 47:55-71.

Fry, DH Jr. 1963. Potential profits in the California salmon fishery. California Fish and Game 49:256-267.

Fry, DH Jr, Hughes, EP. 1952. A sampling program for recovery of marked king and silver salmon. California Fish and Game 38:535-540.

Fry, DH Jr, Hughes, EP. 1951. The California salmon troll fishery. Pacific Marine Fisheries Commission Bulletin 2:7-42.

Fry, DH Jr, Hughes, EP. 1952. A sampling program for recovery of marked king and silver salmon. California Fish and Game 38:535-540.

Fukushima, M, Quinn, TP, Smoker, WW. 1998. Estimation of eggs lost from superimposed pink salmon (*Oncorhynchus gorbuscha*) redds. Canadian Journal of Fisheries and Aquatic Sciences 55:618-625.

Fulton, TW. 1904. The rate of growth of fishes. Fisheries Board of Scotland, Annual Report 22 (Part 3) 141-241.

Gaines, PC, Martin, CD. 2004. Feasibility of dual-marking age-0 Chinook salmon for mark-recapture studies. North American Journal of Fisheries Management 24:1456-1459.

Gaines, PD, Martin, CD. 2002. Abundance and seasonal, spatial, and diel distribution patterns of juvenile salmonids passing the Red Bluff Diversion Dam, Sacramento River. Red Bluff, California: United States Fish and Wildlife Service.

Gallager, SP, Gard, MF. 1999. Relationship between Chinook salmon (*Oncorhynchus tshawytscha*) redd densities and PHABSIM-predicted habitat in the Merced and Lower American rivers, California. Canadian Journal of Fisheries and Aquatic Sciences 56:570-577.

Gangmark, HA, Bakkala, RG. 1960. A comparative study of unstable and stable (artificial channel) spawning streams for incubating king salmon at Mill Creek. California Fish and Game 46:151-163.

Gangmark, HA, Broad, RD. 1955. Experimental hatching of king salmon in Mill Creek, a tributary of the Sacramento River. California Fish and Game 41:233-242.

Gangmark, HA, Broad, RD. 1956. Further observations on stream survival of king salmon spawn. California Fish and Game 42:37-49.

Gangmark, HA, Sanford, FB. 1963. Theory on development of mounds near Red Bluff, Calif. Fishery Bulletin 63:213-200.

Ganssle, D. 1966. Fishes and decapods of San Pablo and Suisun bays. In: Turner, JL, Kelley, DW, editors. Ecological studies of the Sacramento-San Joaquin estuary. Fish Bulletin 133 . p. 64-94.

Ganssle, D. 1962. Annual Report (1961-1962). Sacramento, California: Delta Fish and Wildlife Protection Study, Resources Agency of California.

Ganssle, D, Kelley, DW. 1963. Sacramento, California: Resources Agency of California. Delta Fish and Wildlife Protection Study, Appendix A.

Garcia, A. 1989. The impacts of squawfish predation on juvenile Chinook salmon at Red Bluff Diversion Dam and other locations in the Sacramento River. U.S. Fish and Wildlife Service. USFWS Report No. AFF/FAO- 89-05.

Gavrilets, S. 2004. Fitness landscapes and the origin of species. Monographs in Population Biology. Princeton University Press.

Geist, DR. 2000. Hyporheic discharge of river water into fall chinook salmon (*Oncorhynchus tshawytscha*) spawning areas in the Hanford Reach, Columbia river. Canadian Journal of Fisheries and Aquatic Sciences 57:1647-1656.

Geist, DR, Dauble, DD. 1998. Redd site selection and spawning habitat use by fall chinook salmon: the importance of geomorphic features in large rivers. Environmental Management 22:655-669.

Geist, DR, Hanrahan, TP, Arntzen, EV, McMichael, GA, Murrya, CJ, Chien, Y-J. 2002. Physiochemical characteristics of the hyporheic zone affect redd site selection by chum salmon and fall chinook salmon in the Columbia River. North American Journal of Fisheries Management 22:1077-1085.

Geist, DR, Jones, J, Murray, CJ, Dauble, DD. 2000. Suitability criteria analyzed at the spatial scale of redd clusters improved estimates of fall chinook salmon (*Oncorhynchus tshawytscha*) spawning habitat use in the Hanford Reach, Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 57:1636-1646.

Gharrett, AJ, Smoker, WW. 1991. Two generations of hybrids between even- and odd-year pink salmon (*Oncorhynchus gorbuscha*); a test for outbreeding depression. Canadian Journal of Fisheries and Aquatic Sciences 48:1744-1749.

Giannico, GR. 2000. Habitat selection by juvenile coho salmon (*Oncorhynchus kisutch*) in response to food and woody debris manipulations in suburban and rural stream sections. Canadian Journal of Fisheries and Aquatic Sciences 57:1804-1813.

Giannico, GR, Healey, MC. 1999. Ideal free distribution theory as a tool to examine juvenile coho salmon (*Oncorhynchus kisutch*) habitat choice under different conditions of food abundance and cover. Canadian Journal of Fisheries and Aquatic Sciences 56:2362-2373.

Gilbert, CH. 1913. Age at maturity of the Pacific coast salmon of the genus *Oncorhynchus*. Bulletin of the Bureau of Fisheries.

Gilbert, J, Danielopol, DL, Stanford, JA. 1994. Groundwater ecology. San Diego, California: Academic Press.

Gilliam, JF, Fraser, DF. 1987. Habitat selection under predation hazard: test of a model with foraging minnows. Ecology 68:

Gillilan, DM and Brown, TC. 1997. Instream flow protection: seeking a balance in western water use. Washington, D.C.: Island Press.

Gingras, M. 1997. Mark/recapture experiments at Clifton Court Forebay to estimate pre-screening loss to juvenile fishes: 1976-1993. Interagency Ecological Program for the San Francisco Bay/Delta Estuary.

Ginzburg, LR, Jensen, CXJ. 2004. Rules of thumb for judging ecological theories. Trends in Ecology and Evolution 19:121-126.

Giorgi, AE, Hillman, TW, Stevenson, JR, Hays, SG, Peven, CM. 1997. Factors that influence the downstream migration rates of juvenile salmon and steelhead through the hydroelectric system in the mid-Columbia River basin. North American Journal of Fisheries Management 17:268-282.

Girard, P, Bosclair, D, Leclerc, M. 2004. The effect of cloud cover on the development of habitat quality indices for juvenile Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 60:1386-1397.

Goals Project. 1999. Baylands ecosystem habitat goals. A report of habitat recommendations prepared by the San Francisco Bay Area wetlands ecosystem goals project. U. S. Environmental Protection Agency, San Francisco, California San Francisco Regional Water Quality Control Board, Oakland, California.

Gobalet, KW, Schulz, PD, Wake, TA, Siefkin, N. 2004. Archaeological perspectives on Native American fisheries of California, with emphasis on steelhead and salmon. Transactions of the American Fisheries Society 133:801-833.

Godin, J-GJ. 1981. Migrations of salmonid fishes during early life history phases: daily and annual timing. In: Brannon, EL, Salo, EO, editors. Proceeding of the salmon and trout migratory behavior symposium. Seattle, Washington: School of Fisheries, University of Washington. p. 22-50.

Goede, RW, Barton, BA. 1990. Oganosomatic indices and an autopsy-based assessment as indicators of health and condition of fish. American Fisheries Society Symposium 8:93-108.

Goldwasser, L, Mohr, MS, Grover, AM, Plamen-Zwahlen, ML. 2001. The supporting databases and biological analyses for the revision of the Klamath ocean harvest model . National Marine Fisheries Service and California Department of Fish and Game.

Good, TP, Waples, RS, Adams, P. 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U. S. Dept. of Commerce, NOAA Tech. Memo. NMFS-WSFSC-66.

Goodman, D. 2004. Salmon supplementation: demography, evolution, and risk assessment. In: Nickum, MJ, Mazik, PM, Nickum, JG, MacKinley, DD, editors. Propagated fish in resource management. American Fisheries Society, Symposium 44. Bethesda, Maryland: American Fisheries Society. p. 217-232.

Goodman, D. 2005. Selection equilibrium for hatchery and wild spawning fitness in integrated breeding programs. Canadian Journal of Fisheries and Aquatic Sciences 62:374-389.

Gotceitas, V, Godin, J-G. 1991. Foraging under risk of predation in juvenile Atlantic salmon (*Salmo salar*): effects of social status and hunger. Behavioral Ecology and Sociobiology 29:255-261.

Gowan, C, Fausch, KD. 2002. Why do foraging salmonids move during summer? Environmental Biology of Fishes 64:139-153.

Grant, JWA, Kramer, DL. 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Fisheries and Aquatic Sciences 47:1724-1737.

Grant, JWA, Steinrimsson, SO, Keeley, ER, Cunjak, RA. 1998. Implications of territory size for the measurement and prediction of salmonid abundance in streams. Canadian Journal of Fisheries and Aquatic Sciences 55 (Supplement 1):181-190.

Grant, PR, Grant, BR. 2002. Unpredictable evolution in a 30-year study of Darwin's finches. Science 296:707-711.

Grant, WS. 1997. Genetic effects of straying of non-native hatchery fish into wild populations: proceedings of the workshop . NOAA NMFS-NWFSC Technical Memorandum 30 .

Greco, SE. 1999. Monitoring riparian landscape change and modeling habitat dynamics of the yellow-billed cuckoo on the Sacramento River, California [dissertation]. University of California, Davis.

Greene, CW. 1926. The physiology of the spawning migration. Physiological Review 6:201-241.

Greene, CM, Beechie, TJ. 2004. Consequences of potential density-dependent mechanisms on recovery of ocean-type Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 61:590-602.

Greene, CM, Jensen, DW, Pess, GR, Steel, EA, Beamer, E. 2005. Effects of environmental conditions during stream, estuary, and ocean residency on Chinook salmon return rates in the Skagit River, Washington. Transactions of the American Fisheries Society 134:1562-1581.

Greene, S. 1992. Daily fork-length table from data by Frank Fisher, California Department of Fish and Game. Sacramento, California: California Department of Water Resources, Environmental Services Division.

Greenland, S, Robins, J. 1994. Invited commentary: ecologic studies --biases, misconceptions, and counter-examples. American Journal of Epidemiology 139:747-760.

Greenwald, GM, Earley, JT, Brown, MR. 2003. Juvenile salmonid monitoring in Clear Creek, California, from July 2001 to July 2002. Red Bluff, California: United States Fish and Wildlife Service.

Gregory, RS, Levings, CD. 1998. Turbidity reduces predation on migrating Pacific salmon. Transactions of the American Fisheries Society 127:275-285.

Gregory, R, Failing, L, Higgins, P. 2006. Adaptive management and environmental decision making: a case study application to water use planning. Ecological Economics 58:434-447.

Gregory, SV, Boyer, KL, Gurnell, AM. 2003. The ecology and management of wood in world rivers. American Fisheries Society Symposium. Bethesda, Maryland: American Fisheries Society.

Gringas, M. 1997. Mark/recapture experiments at Clifton Court Forebay to estimate pre-screening loss to juvenile fishes: 1976-1993. Interagency Ecological Program for the San Francisco Bay/Delta Estuary. Technical Report.

Groot, C, Margolis, L. 1991. Pacific salmon life histories. Vancouver: UBC Press.

Groot, C, Margolis, L, Clarke, WC. 1995. Physiological Ecology of Pacific salmon. Vancouver: UBC Press.

Gross, MR. 1998. One species with two biologies: Atlantic salmon (*Salmo salar*) in the wild and in aquaculture. Canadian Journal of Fisheries and Aquatic Sciences 55 (Suppl. 1):131-144.

Groves, PA, Chandler, JA. 1999. Spawning habitat used by fall Chinook salmon in the Snake River. North American Journal of Fisheries Management 19:912-922.

Guay, JC, Boisclair, D, Rioux, D, Leclerc, M, Lapointe, MLP. 2000. Development and validation of numerical

habitat models for juveniles of Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 57:2065-2075.

Guay, JC, Bosclair, D, Leclerc, M, Lapointe, M. 2004. Assessment of the transferability of biological habitat models for Atlantic salmon parr (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 60:1398-1408.

Haefner, JW, Bowen, MD. 2002. Physical-based model of fish movement in fish extraction facilities. Ecological Modeling 152:227-245.

Hagen, P, Meerburg, D, Myers, K, Rogatnykh, A, Urawa, S, Volk, E. 2001. Workshop on salmonid otolith marking, 21 March 2001, Seattle, Washington. Technical Report 3. North Pacific Anadromous Fish Commission.

Hallock, RJ, Elwell, RF, Fry, DHJr. 1970. Migrations of adult king salmon (*Oncorhynchus tshawytscha*) in the San Joaquin Delta as demonstrated by the use of sonic tags. Fish Bulletin 151. California Department of Fish and Game.

Hallock, RJ, Warner, GH, Fry, DHJr. 1952. California's part in a three-state salmon fingerling marking program. California Fish and Game 38:301-332.

Hallock, RJ. undated. The status of inland habitat and factors adversely impacting salmon resources. California Department of Fish and Game, Anadromous Fisheries Branch .

Hallock, RJ. 1977. Status of Sacramento River system salmon resource and escapement goals. California Department of Fish and Game.

Hallock, RJ, Fry, DH. 1967. Five species of salmon, *Oncorhynchus*, in the Sacramento River. California. California Fish and Game 53:5-2.

Hallock, RJ, Fry, DH, LaFaunce, DA. 1957. The use of wire fyke traps to estimate the runs of adult salmon and steelhead in the Sacramento River. California Fish and Game 43:271-298.

Hallock, RJ, Reisenbichler, RR. 1979. Evaluations of returns from Chinook salmon, *Oncorhynchus tshawytscha*, released at Coleman and Nimbus hatcheries and in the Sacramento River estuary. California Department of Fish and Game, Anadromous Fisheries Branch. Office report.

Hallock, RJ, Reisenbichler, RR. 1980. Freshwater and ocean returns of marked winter-run and late fall-run Chinook salmon, *Oncorhynchus tshawytscha*, from the Sacramento River . California Department of Fish and Game, Anadromous Fisheries Branch. Office report.

Hallock, RJ, Van Woert, WF. 1959. A survey of anadromous fish losses in irrigation diversions from the Sacramento and San Joaquin rivers. California Fish and Game 45:227-296.

Hallock, RJ, Van Woert, WF, Shapovalov, L. 1961. An evaluation of stocking hatchery-reared steelhead rainbow trout *(Salmon gairdnerii gairdnerii)* in the Sacramento River System. Fish Bulletin No. 114. California Department of Fish and Game.

Ham, KD, Pearsons, TN. 2000. Can reduced salmonid population abundance be detected in time to limit management impacts. Canadian Journal of Fisheries and Aquatic Sciences 57:17-24.

Hampton, M. 1988. Development of habitat preference criteria for anadromous salmonids in the Trinity River. Sacramento, California: U. S. Fish and Wildlife Service.

Hankin, DG, Healey, MC. 1986. Dependence of exploitation rates for maximum yield and stock collapse on age and sex structure of chinook salmon (*Oncorhynchus tshawytscha*) stocks. Canadian Journal of Fisheries and Aquatic Sciences 43:1746-1759.

Hankin, DG, McKelvey, R. 1985. Comment on fecundity of chinook salmon and its relevance to life history theory. Canadian Journal of Fisheries and Aquatic Sciences 42:393-394.

Hankin, DG, Nicholas, JW, Downey, TW. 1993. Evidence for inheritance of age at maturity in chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 50:347-358.

Hannon, J, Healey, M. 2002. American River steelhead redd surveys, 2001-2002. Sacramento, California: U. S. Bureau of Reclamation and California Department of Fish and Game.

Hannon, J, Healey, M, Deason, B. 2003. American River steelhead (*Oncorhynchus mykiss*) spawning, 2001-2003. Sacramento, California: U. S. Bureau of Reclamation and California Department of Fish and Game.

Hanrahan, TP, Dauble, DD, Geist, DR. 2004. An estimate of Chinook salmon (*Oncorhynchus tshawytscha*)

spawning habitat and redd capacity upstream of a migration barrier in the upper Columbia River. Canadian Journal of Fisheries and Aquatic Sciences 61:23-33.

Hansen, J, Nazakrenko, L, Ruedy, R, Sato, M, Willis, J, Del Genio, A, Kock, D, Lacis, A, Lo, K, Menon, S, Novakov, T, Periwitz, J, Russell, G, Schmidt, GA, Tausnev, N. 2005. Earth's energy imbalance: confirmations and implications. Science 308:1431-1435.

Hanski, IL. 1997. Metapopulation dynamics: from concepts and observations to predictive models. In: Hanski, IL, Gilpin, ME, editors. Metapopulation biology: ecology, genetics, evolution. New York: Academic Press. p. 69-92.

Hanski, IL, Gilpin, ME. 1997. Metapopulation biology: ecology, genetics, evolution. New York: Academic Press.

Hanski, I, Gilpin, M. 1991. Metapopulation dynamics: brief history and conceptual domain. Biological Journal of the Linnaean Society 42:3-16.

Hanson, HA, Smith, OR, Needham, PR. 1940. An investigation of fish salvage problems in relation to Shasta Dam. United States Fish and Wildlife Service. Special Scientific Report # 10.

Hanson, HA, Smith, OR, Needham, PR. 1940. An investigation of fish salvage problems in relation to Shasta Dam. Special Scientific Report # 10. Washington, D. C.: U. S. Bureau of Fisheries.

Hard, JJ. 2004. Evolution of Chinook salmon life history under size-selective harvest. In: Hendry, AP, Stearns, SC, editors. Evolution illuminated: salmon and their relatives. Oxford University Press. p. 315-337.

Hard, JJ, Heard, WR. 1999. Analysis of straying variation in Alaskan hatchery Chinook salmon (*Oncorhynchus tshawytscha*) following transplantation. Canadian Journal of Fisheries and Aquatic Sciences 56:578-589.

Harden Jones, FR. 1978. Fish Migration. London: Arnold.

Hare, SR, Mantua, NJ, Francis, RC. 1999. Inverse production regimes: Alaska and West Coast Pacific salmon. Fisheries 24:6-14.

Harmon, ME, Franklin, JF, Swanson, FJ, Sollings, P, Gregory, SV, Lattin, JD, Anderson, NH, Cline, SP, Sumen, NG, Sedell, JR, Lienkaemper, GW, Cromack, KJr, Cummins, KW. 1986. Ecology of coarse woody debris in temperate ecosystems. Advances in Ecological Research 15:133-302.

Hasler, AD, Scholz, AT, Hornall, RM. 1978. Olfactory imprinting and homing in salmon. American Scientist 66:347-355.

Hasler, AD. 1966. Underwater Guideposts. Madison, Wisconsin: University of Wisconsin Press.

Hassan, M. 1990. Scour, fill, and burial depth of coarse material in gravel bed streams. Earth Surface Processes and Landforms 15:341-356.

Hatchery Scientific Review Group (HSRG) - Lars Mobrand (chair), John Barr, Lee Blankenship, Don Campton, Trevor Eyelyn, Conrad Mahnken, Bob Piper, Lisa Seeb and Bill Smoker. 2003b. Emerging issues in hatchery reform: marine carrying capacity. Seattle, Washington: Long Live the Kings.

Hatchery Scientific Review Group (HSRG) - Lars Mobrand (chair), John Barr, Lee Blankenship, Don Campton, Trevor Eyelyn, Conrad Mahnken, Bob Piper, Lisa Seeb and Bill Smoker. 2003a. Hatchery reform recommendations for the Puget Sound and coastal Washington Hatchery Reform Project. Seattle, Washington: Long Live the Kings.

Hatton, SR. 1940. Progress report on the Central Valley fisheries investigations, 1939. California Fish and Game 26:334-369.

Hatton, SR, Clark, GH. 1942. A second progress report on the Central Valley fisheries investigation. California Fish and Game 28:116-123.

Haugen, TO, Vøllestad, LA. 2001. A century of life-history evolution in grayling. Genetica 112-113:475-491.

Haugen, TO, Vøllestad, LA. 2000. Population differences in early life-history traits in greyling. Journal of Evolutionary Biology 13:897-905.

Hawke, SP. 1978. Stranded redds of quinnat salmon in the Mathias River, South Island, New Zealand. New Zealand Journal of Marine and Freshwater Research 12:161-78.

Hayhoe, K, eighteen others. 2004. Emissions pathways, climate change, and impacts on California. Proceedings of the National Academy of Sciences 101:12422-12427.

Healey, MC. 1983. Coastwide distribution and ocean migration patterns of stream- and ocean-type Chinook

salmon, *Oncorhynchus tshawytscha*. Canadian Field Naturalist 97:427-433.

Healey, MC. 1982. Juvenile Pacific salmon in estuaries: the life support system. In: Kennedy, VS, Editor. Estuarine comparisons. New York: Academic Press. p. 315-341.

Healey, MC. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). In: Groot, C, Margolis, L, editors. Pacific salmon life histories. p. 311-394.

Healey, MC. 1986. Optimum size and age at maturity in Pacific salmon and effects of size-selective fisheries. In: Meerburg, DJ, editor. Salmonid age at maturity; p. 39-52. Canadian Special Publication in Fisheries and Aquatic Sciences.

Healey, MC. 2001. Patterns of gametic investment by female stream- and ocean-type chinook salmon.

Healey, MC. 1980. Utilization of the Nanaimo River estuary by juvenile chinook salmon, *Oncorhynchus tshawytscha*. Fishery Bulletin 77:653-668.

Healey, MC. 1994. Variation in the life history characteristics of chinook salmon and its relevance to conservation of the Sacramento winter-run of chinook salmon. Conservation Biology 8:876-877.

Healey, MC, Groot, C. 1987. Marine migration and orientation of ocean-type chinook and sockeye salmon. American Fisheries Society Symposium 1 . p. 298-312.

Healey, MC, Heard, WR. 1984. Inter- and intra-population variation in the fecundity of Chinook salmon (*Oncorhynchus tshawytscha*) and its relevance to life history theory. Canadian Journal of Fisheries and Aquatic Sciences 41:476-483.

Healey, MC, Prince, A. 1995. Scales of variation in life history tactics of Pacific salmon and conservation of phenotype and genotype. In: Nielsen, JL, Powers, DA, editors. Evolution and the aquatic ecosystem: defining unique units in population conservation. American Fisheries Society Symposium 17. Bethesda, Maryland: American Fisheries Society. p. 176-184.

Healey, TP. 1979. The effect of high temperature on the survival of Sacramento River Chinook (king) salmon, *Oncorhynchus tshawytscha*, eggs and fry. California Department of Fish and Game. Anadromous Fisheries Administrative Report 79-10.

Heard, WR. 1998. Do hatchery salmon affect the North Pacific Ocean ecosystem. North Pacific Anadromous Fish Commission Bulletin 1:405-411.

Heard, WR. 1991. Life history of pink salmon (*Oncorhynchus gorbuscha*). In: Groot, C, Margolis, L, editors. Pacific salmon life histories. Vancouver: UBC Press. p. 119-230.

Heard, WR, Burkett, R, Thrower, F, McGee, S. 1995. A review of chinook salmon resources in Southeast Alaska and development of an enhancement program designed for minimal hatchery-wild stock interaction. In: Schramm, HLJ, Piper, RG, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium.

Heath, DD, Blouw, DM. 1998. Maternal effects in fish: are they adaptive or merely physiological side effects? In: Mousseau, TA, Fox, CW, editors. Adaptive maternal effects. Oxford University Press. p. 178-201.

Heath, DD, Fox, CW, Heath, JW. 1999. Maternal effects on offspring size: variation through early development of chinook salmon. Evolution 53:1605-1611.

Heath, DD, Heath, JW, Bryden, CA, Johnson, RM, Fox, CW. 2003. Rapid evolution of egg size in captive salmon. Science 299:1738-1740.

Heath, DD, Moya-Laraño, J, Fox, CW. 2003. Response to comment on "Rapid evolution of egg size in captive salmon". Science 302:59e. www.sciencemag.org/cgi/content/full/302/5642/59e

Hedgecock, D, Banks, MA, Rasbrook, VK, Dean, CA, Blankenship, SM. 2001. Applications of population genetics to conservation of Chinook salmon diversity in the Central Valley. In: Brown, RL, editor. Contributions to the biology of Central Valley salmonids. Fish Bulletin .1. p. 45-70.

Hedgecock, D. 2002. Microsatellite DNA for the management and protection of California's Central Valley chinook salmon (*Oncorhynchus tshawytscha*). University of California, Davis, Bodega Marine Laboratory.

Heggenes, J. 2002. Flexible summer habitat selection by wild, allopatric brown trout in lotic environments. Transactions of the American Fisheries Society 131:287-298.

Heintz, RA, Nilson, BD, Hudson, J, Larsen, M, Holland, L. 2004. Marine subsidies in freshwater: effects of salmon carcasses on lipid class and fatty acid composition of juvenile coho salmon. Transactions of the American

Fisheries Society 133:559-567.

Helsel, DR, Hirsch, RM. 1992. Statistical methods in water resources. Studies in Environmental Sciences . New York: Elsevier.

Hendricks, SP, White, DS. 2000. Stream and groundwater influences on phosphorus biogeochemistry. In: Jones, JB, Mulholland, PJ, editors. Streams and ground waters. San Diego: Academic Press. p. 221-235.

Hendry, AP. 2001. Adaptive divergence and the evolution of reproductive isolation in the wild: an empirical demonstration using introduced sockeye salmon. Genetica 112/113:515-534.

Hendry, AP, Bohlin, T, Jonsson, B, Berg, OK. 2004. To sea or not to sea? Anadromy versus non-anadromy in salmonids. In: Hendry, AP, Stearns, SC, Evolution illuminated: salmon and their relatives. Oxford University Press. p. 92-125.

Hendry, AP, Stearns, SC. 2004. Evolution illuminated: salmon and their relatives. Oxford University Press.

Hendry, AP, Weinbirg. John K., Bemtzen, P, Volk, EC, Quinn, TP. 2000. Rapid evolution of reproductive isolation in the wild: evidence from introduced salmon. Science 290:516-518.

Hennessey, TM. 1994. Governance and adaptive management of estuarine ecosystems: the case of Chesapeake Bay. Coastal Management 22:119-145.

Heubach, W. 1968. Fish and wildlife resources of the San Francisco Bay and Delta: description, environmental requirements, problems, opportunities and the future. California Department of Fish and Game.

Hey, J, Brannon, EL, Campton, DE, Dowle, RW, Fleming, IA, Kinnison, MT, Lande, R, Olsen, J, Philipp, DP, Travis, J, Wood, CC, Doremus, H. 2005. Considering life history, behavioral, and ecological complexity in defining conservation units for Pacific salmon. An independent panel report, requested by NOAA Fisheries.

Higgins, PS, Bradford, MJ. 1996. Evaluation of a large-scale fish salvage to reduce the impacts of controlled flow reduction in a regulated river. North American Journal of Fisheries Management 16:666-673.

Higgins, P. 2001. Using adaptive management for instream flow assessment for water use planning in British Columbia. Burnaby, British Columbia: BC Hydro, Water Use Planning, Fisheries Advisory Team.

Higgs, DA, Macdonald, JS, Levings, CD, Dosanjh, BS. 1995. Nutrition and feeding habits in relation to life history stage. In: Groot, C, Margolis, L, Clarke, WC, editors. Physiological ecology of Pacific salmon. Vancouver: University of British Columbia Press. p. 159-316.

Hilborn, R. 1985. Apparent stock-recruitment relationship in mixed stock fisheries. Canadian Journal of Fisheries and Aquatic Sciences 42:718-723.

Hilborn, R. 1998. The economic performance of marine stock enhancement projects. Bulletin of Marine Science 62:661-674.

Hilborn, R. 1992. Hatcheries and the future of salmon in the Northwest. Fisheries 17:5-8.

Hilborn, R. 1997. Statistical hypothesis testing and decision theory in fisheries science. Fisheries 22:19-20.

Hilborn, R, Coronado, C. 1997. Changes in ocean survival of coho and Chinook salmon in the Pacific Northwest. In: Emmett, RI, Schiewe, MH, editors. Estuarine and ocean survival of northeastern Pacific salmon: proceedings of the workshop. NOAA Technical Memorandum. U. S. Dept. of Commerce.

Hilborn, R, Eggers, D. 2000. A review of hatchery programs in Prince Williams Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society 129:333-350.

Hilborn, R, Eggers, D. 2000. A review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society 129:333-350.

Hilborn, R, Eggers, D. 2001. A review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska: response to comment. Transactions of the American Fisheries Society 130:720-724.

Hilborn, R, Ludwig, D. 1993. The limits of applied ecological research. Ecological Applications 3:550-552.

Hilborn, R, Mangel, M. 1997. The ecological detective: confronting models with data. Monographs in Population Biology. Princeton, New Jersey: Princeton University Press.

Hilborn, R, Quinn, TP, Schindler, DE, Rogers, DE. 2003. Biocomplexity and fisheries sustainability . Proceedings of the National Academy of Sciences 100:6564-6568.

Hilborn, R and Walters, CJ. 1992. Quantitative fisheries stock assessment: choice, dynamics and uncertainty. New York: Chapman & Hall.

Hill, J, Grossman, GD. 1993. An energetic model of microhabitat use for rainbow trout and rosyside dace. Ecology 74:685-698.

Hill, KA, Webber, JD. 1999. Butte Creek Spring-Run Chinook Salmon, *Oncorhynchus tshawytscha*, Juvenile Outmigration and Life History, 1995-1998. California Dept. of Fish and Game . Inland Fisheries Administrative Report No. 99-5.

Hindar, KRN, Utter, F. 1991. Genetic effects of cultured fish on natural fish populations. Canadian Journal of Fisheries and Aquatic Sciences 48:945-957.

Hinke, JT, Foley, DG, Wilson, C, Watters, GM. 2005. Persistent habitat use by Chinook salmon *Oncorhynchus tshawytscha* in the coastal ocean. Marine Ecology Progress Series 304:207-220.

Hinke, JT, Watters, GM, Boehlert, GW, Zedonis, P. 2005. Ocean habitat use in autumn by Chinook salmon in coastal waters of Oregon and California. Marine Ecology Progress Series 285:181-192.

Hobbs, DF. 1937. Natural reproduction of quinnat salmon, brown and rainbow trout in certain New Zealand waters. New Zealand Marine Department Fishery Bulletin 6:

Hobbs, DF. 1940. Natural reproduction of trout in New Zealand and its relation to density of populations. New Zealand Marine Department Fishery Bulletin 8:

Hobbs, NT, Hanley, TA. 1990. Habitat evaluation: do use/availability data reflect carrying capacity. Journal of Wildlife Management 54:515-522.

Hodge, RJ. 1990. Statement of Decision, Environmental Defense Fund, Inc. et al., v. East Bay Municipal Utility District, et al. Hayward, California: Superior Court, Alameda County, California. Case No. 425955.

Høgåsen, HR. 1998. Physiological changes associated with the diadromous migration of salmonids. Canadian Special Publication of Fisheries and Aquatic Sciences 127.

Holm, CF, Armstran, JD, Gilvear, DJ. 2001. Investigating a major assumption of predictive instream habitat models: is water velocity preference of juvenile Atlantic salmon independent of discharge. Journal of Fish Biology 59:1653-1666.

Holtby, LB, Healey, MC. 1985. Selection for adult size in female coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 43:1946-1959.

Horner, T, Titus, R, Brown, M. 2003. Phase 3 gravel assessment on the lower American River, draft. California State University Sacramento:

Hubbs. C. L. 1943. Terminology of the early stages of fish. Copeia 4:260.

Hughes, NF, Dill, LM. 1990. Position choice by drift-feeding salmonids: model and test for Arctic grayling (*Thaymallus arcticus*) in subarctic mountain streams, interior Alaska. Canadian Journal of Fisheries and Aquatic Sciences 47:2939-2048.

Hughes, NF. 2000. Testing the ability of habitat selection theory to predict interannual movement patterns of a drift-feeding salmonid.

Hughes, NF, Grand, TC. 2000. Physiological ecology meets the ideal-free distribution: predicting the distribution of size-structured fish populations across temperature gradients. Environmental Biology of Fishes 59:285-298.

Hughes, NF, Hayes, JW, Shearer, KA, Young, RA. 2003. Testing a model of drift-feeding using three-dimensional videography of wild brown trout, *Salmo trutta*, in a New Zealand River. Canadian Journal of Fisheries and Aquatic Sciences 60:1462-1476.

Hunt, SL, Mulligan, TJ, Komori, K. 1999. Oceanic feeding habitats of chinook salmon, *Oncorhynchus tshawytscha*, off Northern California. Fishery Bulletin 97:717-721.

Huntingford, FA. 2004. Implications of domestication and rearing conditions for the behaviour of cultivated fishes. Journal of Fish Biology 65(SA):122-142.

Huntingford, FA, Metcalf, NB, Thorpe, JE. 1988. Choice of feeding station in Atlantic salmon, Salmo salar, parr: effects of predation risk, season and life history strategy. Journal of Fish Biology 33:917-924.

Huntington, CW. 1985. Deschutes River spawning gravel study, Volume 1. Beaverton, Oregon:

Incerpi, A. 1996. Hatchery-bashing: a useless pastime. Fisheries 21:28.

Independent Scientific Advisory Board (ISAB). 2002. Hatchery surpluses in the Pacific Northwest. Fisheries 27:16-27.

Independent Scientific Advisory Board (ISAB). 2003. Review of salmon and steelhead supplementation. Portland,

Oregon:

Independent Scientific Group (ISG). 2000. Return to the River - 2000. Portland, Oregon: Northwest Power and Conservation Council. Council Document 2000-12.

Independent Scientific Group (ISG). 1999. Scientific issues in the restoration of salmonid fishes in the Columbia River. Fisheries 24 (3):10-19.

Iron Mountain Mine Trustee Council (IMMTC). 2002. Final restoration plan for natural resource injuries from Iron Mountain Mine.

Isaac, DJ, Thurow, RF. 2006. Network-scale spatial and temporal variation in Chinook salmon (*Oncorhynchus tshawytscha*) redd distributions: patterns inferred from spatially continuous replicate surveys. Canadian Journal of Fisheries and Aquatic Sciences 63:285-296.

Wilma, GK, Thomas, PT, Forsyth, RB, Vijay an, MM.. 1998. Heat shock protein expression in fish. Reviews in Fish Biology and Fisheries 8:35-56.

Jackson, TA. 1992. Microhabitat utilization by juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in relation to discharges in the lower American River [ms thesis]. Corvallis: Oregon State University.

Jager, HI, Cardwell, HE, Sale, MJ, Bevelheimer, MS, Coutant, CC, Van Winkle, W. 1997. Modeling the linkages between flow management and salmon recruitment in rivers. Ecological Modeling 103:171-191.

Jager, HI, Rose, KA. 2003. Designing optimal flow patterns for fall chinook salmon in a Central Valley, California, river. North American Journal of Fisheries Management 23:1-21.

Jassby, A, Van Nieuwenhuyse, EE. 2005. Low dissolved oxygen in an estuarine channel (San Joaquin River, California): mechanisms and models based on long-term time series. San Francisco Estuary and Watershed Science (online serial) 3:Article 2. http://repositories.cdlib.org/jmie/sfews/vol2/iss2/art2.

Jensen, AL, Duncan, RN. 1971. Homing of transplanted coho salmon. Progressive Fish-Culturist 33:216-218.

Jensen, P. 1972. King salmon. In: Skinner, JE, editor. Ecological studies of the Sacramento-San Joaquin estuary. Report No. 8. Sacramento, California: Delta fish and wildlife protection study, Resources Department of California.

Jobling, M. 1995. Environmental Biology of Fishes. Fish and Fisheries Series 16. London: Chapman & Hall.

Johnson, DH. 1999. The insignificance of statistical significance testing. Journal of Wildlife Management 63:763-772.

Johnson, N, Jonsson, B. 2003. Energy allocation among developmental stages, age groups, and types of Atlantic salmon (*Salmo salar*) spawners. Canadian Journal of Fisheries and Aquatic Sciences 60:506-516.

Johnson, RA. 1980. Oxygen transport in salmon spawning gravels. Canadian Journal of Fisheries and Aquatic Sciences 37:155-162.

Johnson, RR, Weigland, DC, Fisher, FW. 1992. Use of growth data to determine the spatial and temporal distribution of four runs of juvenile Chinook salmon in the Sacramento River, CA. United States Fish and Wildlife Service.

Johnson, SL. 1988. The effect of the 1983 El Niño on Oregon's coho (*Oncorhynchus kisutch*) and Chinook (*O. tshawystcha*) salmon. Fisheries Research 6:105-123.

Johnsson, J, Clarke, WC. 1988. Development of seawater adaptation in juvenile steelhead trout (*Salmo gairdneri*) and domesticated rainbow trout (*Salmo gairdneri*) - effects of size, temperature and photoperiod. Aquaculture 71:247-263.

Johnsson, JI, Blackburn, J, Clarke, WC, Withler, RE. 1997. Does presmolt growth rate in steelhead trout (*Oncorhynchus mykiss*) and coho salmon (*Oncorhynchus kisutch*) predict growth rate in seawater. Canadian Journal of Fisheries and Aquatic Sciences 54:430-433.

Johnston, NT, MacIsaac, EA, Tschaplinski, PJ, Hall, KJ. 2004. Effects of the abundance of spawning sockeye salmon (*Oncorhynchus nerka*) on nutrients and algal biomass in forested streams. Canadian Journal of Fisheries and Aquatic Sciences 61:384-403.

Joint Hatchery Review Committee (JHRC). 2001. Final Report on Anadromous Salmonid Fish Hatcheries in California, Review Draft. California Department of Fish and Game and National Marine Fisheries Service Southwest Region.

Jones, JW. 1959. The salmon. London: Collins.

Jones, JB, Mulholland, PJ. 2000. Streams and ground waters. San Diego: Academic Press.

Jones, NE, Tonn, WM. 2004. Resource selection functions for age-0 Arctic grayling (*Thymallus arcticus*) and their application to stream habitat compensation. Canadian Journal of Fisheries and Aquatic Sciences 61:1736-1746.

Jongman, RHG, ter Braak, CJF, van Tongeren, FR. 1987. Data analysis in community and landscape ecology. Wageningen, the Netherlands: Center for Agricultural Publishing and Documentation (PUDOC).

Jonnson, B, Jonnson, N. 1993. Partial migration: niche shift versus sexual maturation in fishes. Reviews in Fish Biology and Fisheries 3:348-365.

Jonsson, NJB, Flemming, IA. 1996. Does early growth cause a phenotypically plastic response in egg production of Atlantic salmon. General and Comparative Endocrinology 10:89-96.

Jordan, DS. 1885. The lower vertebrates. In: Kingsley, JS, The riverside natural history. 3. Cambridge: The Riverside Press. p. 134-168.

Kapuscinski, AR. 1997. Rehabilitation of Pacific salmon in their ecosystems: what can artificial propagation contribute? In: Stouder, DJ, Bisson, PA, Naiman, RJ, Editors. Pacific salmon and their ecosystems. Chapman and Hall. p. 493-512.

Karl, HA, Chin, JL, Ueber, E, Stuaffer, PH, Hendley, JWI. United States Geological Survey. 1991. Beyond the Golden Gate - oceanography, geology, biology and environmental issues in the Gulf of the Farallones. Reston, Virginia: USGS Circular 11-98.

Keeley, ER. 2003. An experimental analysis of self-thinning in juvenile steelhead trout. Oikos 102:543-550.

Keeley, ER. 2000. An experimental analysis of territory size in juvenile steelhead trout. Animal Behavior 59:477-490.

Kelley, DW. 1968. Fish and wildlife resources of the San Francisco Bay and Delta: description, environmental requirements, problems, opportunities and the future. Sacramento: Resources Agency of California.

Kelley, DW. 1966. Ecological studies of the Sacramento-San Joaquin Estuary. Part 1: zooplankton, zoobenthos, and fishes of San Pablo and Suisun bays, zooplankton and zoobenthos of the Delta. Fish Bulletin 133. California Department of Fish and Game.

Kelley, R. 1989. Battling the inland sea. Berkeley: University of California Press.

Kemp. P. S., Gilvear, DJ, Armstrong, JD. 2003. Do juvenile Atlantic salmon parr track local changes in water velocity. Rivers: Research and Applications 19:569-575.

Kennedy, BP, Klaue, A, Blum, JD, Folt, CL, Nislow, KH. 2002. Reconstructing the lives of fish using Sr isotopes in otoliths. Canadian Journal of Fisheries and Aquatic Sciences 59:925-929.

Kerstetter, TH, Keeler, M. 1976. Smolting is steelhead trout (*Salmo gairdneri*): a comparative study of populations in two hatcheries and the Trinity River, Northern California, using gill Na, K, ATPase assays. Arcata, California: Humboldt State University Publication SG 9.

Kimmerer, W, Hagar, JM, Garcia, J, Williams, T. 1989. Chinook population model for the Sacramento River basin, version CPOP-2. Tiburon, California: Biosystems Analysis, Inc.

Kimmerer, WJ. 2004. Open water processes of the San Francisco Estuary: from physical forcing to biological response. San Francisco Estuary and Watershed Science (online serial) 2:Article 1. http://repositories.edlib.org/jmie/sfews/vol2/iss1/art1.

Kimmerer, WJ. 2002. Physical, biological, and management responses to variable freshwater inflow into the San Francisco Estuary. Estuaries 25:1275-1290.

Kimmerer, W, Jones & Stokes Associates. 1999. Conceptual framework for the Sacramento River Chinook salmon individual-based model . Sacramento, California: Draft report to U. S. Fish and Wildlife Service.

Kimmerer, W, Mitchell, B, Hamilton, A. 2001. Building models and gathering data: can we do this better? In: Brown, RL, editor. Contributions to the biology of Central Valley salmonids, Fish Bulletin 179. 2. 2001: California Department of Fish and Game.

Kincaid, HL. 1993. Selective breeding and domestication. In: Cloud, JG, Thorgaard, GH, editors. Genetic conservation of salmonid fishes; New York: Plenum Press.

Kindopp, J. 2003. Growth investigations of wild juvenile steelhead (Oncorhynchus mykiss) in the Feather River using mark and recapture techniques. California Department of Water Resources. Interim Report SP-F10, Task B.

King, HR, Pankhurst, NW, Watts, M, Pankhurst, PM. 2003. Effect of elevated summer temperatures on gonadal steroid production, vitellogenesis and egg quality in female Atlantic salmon. Journal of Fish Biology 63:153-167.

King, J. 2005. Sidney, British Columbia: North Pacific Marine Science Organization (PICES). Pices Scientific Report No. 28.

Kinnison, MT, Hendry, AP. 2004. From macro- to micro-evolution: tempo and mode in salmonid evolution. In: Hendry, AP, Stearns, SC, editors. Evolution illuminated, salmon and their relatives. p. 208-231.

Kinnison, MT, Unwin, MJ, Hendry, AP, Quinn, TP. 2001. Migratory costs and the evolution of egg size and number in introduced and indigenous salmon populations. Evolution 55:1656-1667.

Kjelson, MA, Greene, S, Brandes, PL. 1989. A model for estimating mortality and survival of fall-run Chinook smolts in the Sacramento River Delta between Sacramento and Chipps Island. Stockton, California: United States Fish and Wildlife Service.

Kjelson, M. A., Raquel P. F., and Fisher, F. W. Influences of freshwater inflow on Chinook salmon (*Oncorhynchus tshawytscha*) in the Sacramento-San Joaquin Estuary. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS 81/04. p. 88-108. . FR 32(4). 81.

Kjelson, MA, Raquel, PF, Fisher, FW. 1982. Life history of fall-run juvenile chinook salmon, *Oncorhynchus tshawytscha*, in the Sacramento-San Joaquin Estuary, California. In: Kennedy, VS, editor. Estuarine comparisons. New York: Academic Press. p. 393-411.

Klemetsen, A, Amundsen, P-A, Dempson, JB, Jonsson, B, Jonsson, N, O'Connell, MF, Mortensem. E. 2003. Atlantic salmon *Salmo salar* L.. brown trout Salmo trutta L. and arctic charr *Salvelinus alpinus* (L.): a review of aspects of their life histories. Ecology of Freshwater Fish 12:1-59.

Knowles, N, Cayan, DC. 2002. Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary. Geophysical Research Letters 29:1891, doi:10.1029/2001GLO14339.

Kondolf, GM, Falzone, A, Schneider, DK. 2001. Reconnaissance-level assessment of channel change and spawning habitat on the Stanislaus River below Goodwin Dam. Berkeley, California: GM Kondolf.

Kondolf, GM. 2000. Assessing salmonid spawning gravel quality. Transactions of the American Fisheries Society 129:262-281.

Kondolf, GM, Larsen, EW, Williams, JG. 2000. Measuring and modeling the hydraulic environment for assessing instream flows. North American Journal of Fisheries Management 20:1016-1028.

Kondolf, GM, Sale, MJ, Wolman, MG. 1992. Modification of fluvial gravel size by spawning salmonids. Water Resources Research 29:2265-2274.

Kondolf, GM, Vick, JC, Ramirez, TM. 1996. Salmon spawning habitat rehabilitation in the Merced, Tuolumne, and Stanislaus Rivers, California: an evaluation of project planning and performance. Centers for Water and Wildland Resources, University of California .

Kondolf, GM, Wolman, MG. 1993. The sizes of spawning gravels. Water Resources Research 29:2275-2285.

Kope, RG, Botsford, LW. 1988. Detection of environmental influence on recruitment using abundance data. Canadian Journal of Fisheries and Aquatic Sciences 45:448-458.

Kope, RG, Louis W. Botsford. 1990. Determination of factors affecting recruitment of chinook salmon *Oncorhynchus tshawytscha* in Central California. Fishery Bulletin 88:257-269.

Korman, J, Higgins, PS. 1997. Utility of escapement time series data for monitoring the response of salmon populations to habitat alteration. Canadian Journal of Fisheries and Aquatic Sciences 54:2058-2067.

Koskinen, MT, Haugen, TO, Primmer, CR. 2002. Contemporary fisherian life-history evolution in small salmonid populations. Nature 419:826-830.

Kostow, KE, Marshall, AR, Phelps, SR. 2003. Naturally spawning hatchery steelhead contribute to smolt production but experience low reproductive success. Transactions of the American Fisheries Society 132.:780-790.

Kostow, KE. 2004. Differences in juvenile phenotypes and survival between hatchery stocks and a natural population provide evidence for modified selection due to captive breeding. Canadian Journal of Fisheries and Aquatic Sciences 61:577-589.

Kramer, DL, Rangely, RW, Chapman, LJ. 1997. Habitat selection: patterns of spatial distribution from behavioral

decisions. In: Godin, J-GJ, editor. Behavioral ecology of teleost fishes. Oxford University Press. p. 37-80.

Krebs, CJ. 1998. Ecological methodology. Longman.

Kurth, R. 2003. Redd dewatering and juvenile steelhead and Chinook salmon stranding in the lower Feather River, 2002-2003. California Department of Water Resources.

Kutkuhn, JH. 1963. Estimating absolute age composition of California salmon landings. Sacramento: California Department of Fish and Game. Fish Bulletin 120.

Kwain, W, Thomas, E. 1984. The first evidence of spring spawning by Chinook salmon in Lake Superior. North American Journal of Fisheries Management 4:227-228.

Lande, R. 1976. Natural selection and random genetic drift in phenotypic evolution. Evolution 30:314-334.

Lapointe, M, Eaton, B, Driscoll, S, Latuippe, C. 2000. Modeling the probability of salmonid egg pocket scour due to floods. Canadian Journal of Fisheries and Aquatic Sciences 57:1120-11130.

Larkin, PA. 1977. An epitaph for the concept of maximum sustained yield. Transactions of the American Fisheries Society 106:1-11.

Larkin, PA. 1972. The problem. In: Simon, RC, Larkin, PA, editors. The stock concept in Pacific salmon. H. R. MacMillan Lectures in Fisheries. Vancouver, British Columbia: University of British Columbia. p. 1-18.

Larsen, DA, Beckman, BR, Dickhoff, WW. 2001. The effect of low temperature and fasting during the winter on growth and smoltification of coho salmon. North American Journal of Aquaculture 63:1-19.

Law, PW. 1994. A simulation study of salmon carcass survey by capture-recapture method. California Fish and Game 80:14-28.

Law, R. 2000. Fishing, selection, and phenotypic evolution. ICES Journal of Marine Science 57:659-668.

Lawson, PW, Logerwell, EA, Mantua, NJ, Francis, RC, Agostini, VN. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). Canadian Journal of Fisheries and Aquatic Sciences 61:360-373.

Le Cren, ED. 1951. The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*) . Journal of Animal Ecology 20:201-219.

Ledgerwood, RD, Ryan, BA, Dawley, EM, Nunnallee, EP, Ferguson, JW. 2004. A surface trawl to detect migrating juvenile salmonids tagged with passive integrated transponder tags. North American Journal of Fisheries Management 24:440-451.

Lee, GF, Jones-Lee, A. 2003. Synthesis and discussion of findings on the causes and factors influencing low DO in the San Joaquin River deep water ship channel near Stockton, CA: including 2002 data. El Macero, CA: G. Fred Lee & Associates.

Lehamn, PW, Sevier, J, Guilianotti, J, Johnson, M. 2004. Sources of oxygen demand in the lower San Joaquin River, California. Estuaries 27:405-418.

Levin, PS, Zabel, RW, Williams, JG. 2001. The road to extinction is paved with good intentions: negative association of fish hatcheries with threatened salmon. Proceedings of the Royal Society of London, Series B 268B:1153-1158.

Levings, CD, Lauzier, RB. 1991. Extensive use of the Fraser River basin as winter habitat by juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Zoology 69:1759-1767.

Levings, CD, McAllister, CD, Chang, BD. 1986. Intertidal habitats used by juvenile Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 43:1386-1397.

Levins, R. 1969. Some demographic and genetic consequences of environmental heterogeneity for biological control. Bulletin of the Entomological Society of American 15:237-240.

Levy, DA, Northcote, TG. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. Canadian Journal of Fisheries and Aquatic Sciences 39:270-276.

Lewis, SL. 1969. Physical factors influencing fish populations in pools of a trout stream. Transactions of the American Fisheries Society 89:14-19.

Liao, JC, Beal, DN, Lauder, GV, Triantafyllou, MS. 2003. Fish exploiting vortices decrease muscle activity. Science 302:1566-1569.

Lichatowich, J. 1999. Salmon without rivers. Washington, D. C.: Island Press.

Lichatowich, JA, McIntyre, JD. 1987. Use of hatcheries in the management of anadromous salmonids. In: Dadswell, MJ, Kluada, RJ, Moffitt, CM, Saunders, RL, Rulifson, RA, Cooper, JE, Editors. Common strategies of anadromous and catadromous fish. American Fisheries Society Symposium 1. p. 131-136.

Lichatowich, J. 1998. A conceptual foundation for the management of native salmonids in the Deschutes River. Portland, Oregon: Portland General Electric Company.

Lindley, ST. 2003. Estimation of population growth and extinction parameters from noisy data. Ecological Applications 13:806-813.

Lindley, ST, Mohr, MS. 2003. Modeling the effects of striped bass (*Morone saxatilis*) on the population viability of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*). Fishery Bulletin 101:321-331.

Lindley, ST, Schick, R, May, BP, Anderson, JJ, Greene, S, Hanson, C, Low, A, McEwan, D, MacFarlane, RB, Swanson, C, Williams, JG. 2004. Population structure of threatened and endangered Chinook salmon ESUs in California's Central Valley Basin. NOAA-TN-NMFS-SWFSC-370.

Lindsay, RB, Jonasson, BC, Schroeder, RK, Cates, BC. 1989. Spring Chinook in the Deschutes River, Oregon. Oregon Department of Fish and Wildlife. Information Report 89-4:1.92.

Lisle, TE. 1989. Sediment transport and resulting deposition in spawning gravels, North Coastal California. Water Resources Research 25:1303-1319.

Lisle, TE, Lewis, J. 1992. Effects of sediment transport on survival of salmonid embryos in a natural stream. Canadian Journal of Fisheries and Aquatic Sciences 49:2337-2344.

Lister, DB, Genoe, HS. 1970. Stream habitat utilization by cohabiting underyearlings of Chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) in the Big Qualicum River, British Columbia. Journal of the Fisheries Research Board of Canada 27:1215-1224.

Lister, RB. 1990. Egg size and fecundity as indicators of life history patterns in southern British Columbia Chinook stocks. In: Hassler, TJ, Proceedings of the 1990 Northeast Pacific Chinook and coho salmon workshop; Arcata, CA. California Cooperative Fishery Research Unit, Humboldt State University. p. 128-140.

Littleworth, AL and Garner, EL. 1995. California water. Point Arena, California: Solano Press Books.

Lohmann, KJ, Lohmann, CMF, Ehrhart, LM, Bagley, DA, Swing, T. 2004. Geomagnetic map used in sea-turtle navigation. Nature 428:909-910.

Low, A. 2005. Existing program summary: Central Valley salmon and steelhead monitoring programs . Sacramento, California: California Department of Fish and Game.

Ludwig, D, Walters, CJ. 1985. Are age-structured models appropriate for catch and effort data? Canadian Journal of Fisheries and Aquatic Sciences 42:1066-1072.

Ludwig, D. 1994. Uncertainty and fisheries management. In: Levin, SA, editor. Frontiers in Mathematical Biology. Springer-Verlag. p. 516-528.

Lufkin, A. 1991. California's salmon and steelhead. Berkeley: University of California Press.

Lund, SG, Caissie, D, Cunjak, RA, Vijayan, MM, Tufts, BL. 2002. The effects of environmental heat stress on heat-shock mRNA and protein expression in Miramichi Atlantic salmon (*Salmo salar*) parr. Canadian Journal of Fisheries and Aquatic Sciences 59:1553-1562.

Lynch, M. 1997. Inbreeding depression and outbreeding depression. Grant, W. S. Genetic effects of straying of non-native hatchery fish into natural populations; NOAA Technical Memorandum NMFS NWFSC-30.

Lynch, M, O'Hely, M. 2001. Captive breeding and the genetic fitness of natural populations. Conservation Genetics 2:363-378.

Lynn, RJ, Bograd, SJ, Chereskin, TK, Huyer, A. 2003. Seasonal renewal of the California Current: the spring transition off California. Journal of Geophysical Research 108:3279. doi:10.1029/2003/JC001787

MacFarlane, BR, Ralston, S, Royer, C, Norton, EC. 2005. Juvenile chinook salmon (Oncorhynchus tshawytscha) growth on the Central California coast during the 1980 El Niño and the 1999 La Niña. Fisheries Oceanography 14:

MacFarlane, RB, Norton, EC. 2002. Physiological ecology of juvenile chinook salmon (*Oncorhynchus tshawytscha*) at the southern end of their distribution, the San Francisco Estuary and the Gulf of the Farallones,

California. Fishery Bulletin 100:244-257.

Madenjian, CP, O'Conner, DV, Chernyak, SM, Rediske, RR, O'Keefe, JP. 2004. Evaluation of a Chinook salmon (*Oncorhynchus tshawytscha*) bioenergetics model. Canadian Journal of Fisheries and Aquatic Sciences 61:627-635.

Magnusson, A, Hilborn, R. 2003. Estuarine influence on survival rates of coho (Oncorhynchus kisutch) and Chinook salmon (Oncorhynchus tshawytscha) released from hatcheries on the U. S. Pacific Coast. Estuaries 26:1094-1103.

Mahnken, C, Ruggerone, G, Waknitz, W, Flagg, T. 1998. A historical perspective on salmonid production from Pacific Rim hatcheries. North Pacific Anadromous Fish Commission Bulletin 1:38-53.

Mangel, M. 1994. Climate change and salmonid life history changes. Deep-Sea Research II 41:75-106.

Mangel, M. 1996. Computing expected reproductive success of female Atlantic salmon as a function of smolt size. Journal of Fish Biology 49:877-882.

Mangel, M. 1994. Life history variation and salmonid conservation. Conservation Biology 8:879-880.

Manly, BFJ. 1997. Randomization, bootstrap and Monte Carlo methods in biology, second edition. London: Chapman & Hall.

Manly, BFJ. 2001. Statistics for environmental science and management. Boca Raton, Florida: Chapman & Hall/ CRC.

Manly, BFJ, McDonald, LL, Thomas, DL, McDonald, TL, Erickson, WP. 2002. Resource selection by animals. Kluwer Academic Publishers.

Mantua, NJ, Hare, SR, Zhang, Y, Wallace, JM, Francis, RC. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78:1069-1079.

Marine, KR. 1992. A background investigation and review of the effects of elevated water temperature on reproductive performance of adult Chinook salmon (*Oncorhynchus tshawytscha*). Department of Wildlife and Fisheries Biology, University of California, Davis.

Marine, KR. 1997. Effects of elevated water temperature on some aspects of the physiological and ecological performance of juvenile Chinook salmon (*Oncorhynchus tshawytscha*): implications for management of California's Central Valley salmon stocks [ms thesis]. University of California Davis.

Marine, KR, Cech, JJJr. 2004. Effects of high temperature on growth, smoltification, and predator avoidance in juvenile Sacramento River Chinook salmon. North American Journal of Fisheries Management 24:198-210.

Marr, DHA. 1965. The influence of light and surface contour on the efficiency of development of the salmon embryo. Report of the Challenger Society 3(XVII):33.

Marr, DHA. 1963. The influence of surface contour on the behavior of trout alevins, *S. trutta* L. Animal Behavior 11(2-3):412.

Marthur, D, Bason, WH, Purdy, EJJr, Silver, CA. 1985. A critique of the Instream Flow Incremental Methodology. Canadian Journal of Fisheries and Aquatic Sciences 42:825-831.

Martin, BA, Saiki, MK. 2001. Gut contents of juvenile Chinook salmon from the upper Sacramento River California, during spring 1998. California Fish and Game 87:38-43.

Maser, C, Sedell, JR. 1994. From the forest to the sea: the ecology of wood in streams, rivers, estuaries, and oceans. Delrey Beach, Florida: St. Lucile Press.

Maslin, P, Kindopp, J, Storm, C. 1999. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*): 1999 update. California State University Chico, Dept. of Biological Sciences.

Maslin, P, Lenox, M, Kindopp, J, McKinney, W. 1997. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*). California State University Chico, Dept. of Biological Sciences.

Maslin, PLM, Kindopp, J. 1998. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (*Oncorhynchus tshawytscha*): 1998 update. California State University Chico, Dept. of Biological Sciences.

Mason, JC. 1969. Hypoxial stress prior to emergence and competition among coho salmon fry. Journal of the Fisheries Research Board of Canada 26:63-91.

Matter, AL, Sandford, BP. 2003. A comparison of migration rates of radio- and PIT-tagged adult Snake River Chinook salmon through the Columbia River hydropower system. 23:967-973.

Matthews, KR, Berg, NH. 97. Rainbow trout responses to water temperature and dissolved oxygen stress in two southern California stream pools.

May, RM. 2004. Uses and abuses of mathematics in biology. Science 303:790-793.

Maynard, DJ, Flagg, TA, Mahnken, CVW. 1995. A review of seminatural culture strategies for enhancing the postrelease survival of anadromous salmonids. In: Schramm, HLJr, Piper, RG, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium. p. 307-316.

Maynard D. J., Flagg, TA, Mahnken, CVW, Schroder, SL. 1998. Natural rearing enhancement system technology for salmon culture. In: Brannen, EL, Kinsel, WC, editors. Proceedings of the Columbia River Anadromous Salmonid Rehabilitation and Passage Symposium; Moscow, Idaho. Aquaculture Research Institute, University of Idaho.

Maynard, DJ, Berejikian, BA, Flagg, TA, Riley, S. Resource Enhancement and Utilization Technologies Division, NSC. 2003. Development of a natural rearing system to improve supplemental fish quality: progress report (performance period 1 March 1999 through 28 February 2003). Seattle, Washington: National Marine Fisheries Service.

McCain and Trish and Stillwater Sciences. 2000. Tuolumne River restoration project monitoring : Special Run Pools 9/10, 7/1 Mining Reach, Ruddy Mining Reach. Arcata, California:

McBain and Trush and Stillwater Sciences. 1999. Tuolumne River restoration project monitoring : Special Run Pools 9/10 and Gravel Mining Reach 7/1. Arcata, California:

McCabe, GTJr, Emmett, TC, Muir, WD, Blahm, TH. 1986. Utilization of the Columbia River estuary by subyearling Chinook salmon. Northwest Science 60:133-124.

McCart, P. 1969. Digging behavior of Oncorhynchus nerka spawning in streams at Babine Lake, British Columbia. In: Northcote, TG, Editor. Symposium on salmon and trout in streams. H. R. MacMillian Lectures in Fisheries. Vancouver: University of British Columbia.

McCarthy, E. 1997. CVP Improvement Act update. Western Water http://www/water-ed.org/mayjune97.asp#cvp

McCormick, SD. 1993. Methods for non-lethal gill biopsy and measurement of $Na^+,K^+$ - ATPase activity. Canadian Journal of Fisheries and Aquatic Sciences 50:656-658.

McCormick, SD, Saunders, RL. 1987. Preparatory physiological adaptations for marine life of salmonids: osmoregulation, growth and metabolism. American Fisheries Society Symposium . p. 211-229.

McCullough, DA. 1999. A review and synthesis of effects of alteration to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. Environmental Protection Agency EPA 910-R-99-010. http://www/critfc.org/tech/EPAreport.pdf

McCully, H. 1956. An undescribed type of migration in king salmon, *Oncorhynchus tshawytscha* (Walbaum). California Fish and Game 42:189-918.

McDaniels, TL, Gregory, R. 2004. Learning as on objective within a structured risk management decision process. Environmental Science and Technology 38:19211926.

McElhany, P, Rucklelshaus, MH, Ford, MJ, Wainwright, TC, Bjorksstedt, E. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. NOAA Technical Memorandum NMFS-NWFSC-42.

McEvoy, AF. 1986. The fisherman's problem. Cambridge University Press.

McEwan, D, Nelson, J. 1991. Steelhead restoration plan for the American River. Sacramento, California: California Department of Fish and Game.

McEwan, D. 2001. Central Valley Steelhead. In: Brown, RL, Editor. Contributions to the biology of Central Valley salmonids, Fish Bulletin 179. Fish Bulletin 179.1.California Department of Fish and Game. p. 1-44.

McGinnity, P, Prohöhl, P, Ferguson, A, Hynes, R, Ó Maoiléidigh, Niall, Baker, N, Cotter, D, O'Hea, B, Cooke, D, Rogan, G, Taggart, J, Cross, T. 2003. Fitness reduction and potential extinction of wild populations of Atlantic salmon, *Salmo salar*, as a result of interactions with escaped farm salmon. Proceedings of the Royal Society of London, Series B 270:2443-2450.

McGregor, EA. 1923. Notes on the egg yield of Sacramento River king salmon. California Fish and Game 9:134-138.

McGregor, EA. 1922. Observations on the egg yield of Klamath River king salmon. California Fish and Game 8:160-164.

McHugh, P, Budy, P. 2004. Patterns of spawning habitat selection and suitability for two populations of spring Chinook salmon, with an evaluation of generic versus site-specific suitability criteria. Transactions of the American Fisheries Society 133:89-97.

McIsaac, DO, Quinn, TP. 1988. Evidence for a hereditary component in homing behavior of chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 45:2201-2205.

McLain, Jeff, Burmester, R. 1999. Juvenile fall-run and winter-run Chinook salmon abundance. IEP Newsletter 12:35-38.

McLean, JE, Bentzen, P, Quinn, TP. 2003. Differential reproductive success of sympatric, naturally spawning hatchery and wild steelhead trout (*Oncorhynchus mykiss*) through the adult stage. Canadian Journal of Fisheries and Aquatic Sciences 60:433-440.

McLean, WE. 1979. A rearing model for salmonids [ms thesis]. Vancouver: Department of Interdisciplinary Studies, University of British Columbia.

McMichael, GA, Rakowski, CL, James, BB, Lukas, JA. 2005. Estimated fall Chinook salmon survival to emergence in dewatered redds in a shallow side channel of the Columbia River. North American Journal of Fisheries Management 25:876-884.

McNabb, CD, Liston, CR, Brothwick, SM. 2003. Passage of juvenile Chinook salmon and other fish species through Archimedes lifts and a hidrostal pump at Red Bluff, California. Transactions of the American Fisheries Society 132:326-334.

McNeil, WJ. 1969. Survival of pink and chum salmon eggs and alevins. In: Northcote, TG, editor. Symposium on salmon and trout in streams. H. R. MacMillian Lectures in Fisheries. Vancouver: p. 101-117.

McNeil, WJ. 1962. Variations in the dissolved oxygen content of intragravel water in four spawning streams of Southeastern Alaska. United States Fish and Wildlife Service Special Report - Fisheries No. 402.

McNeil, WJ, Ahnell, WH. 1964. Success of pink salmon spawning relative to size of spawning bed materials. United States Fish and Wildlife Service. Special Scientific Report-Fisheries No. 469.

McPhail, JD. 1997. The origin and speciation on *Oncorhynchus* revisited. In: Stouder, DJ, Bisson, PA, Naiman, RJ, editors. Pacific salmon and their ecosystems. New York: Chapman & Hall. p. 29-40.

Meekan, MG, Dodson, JJ, Good, SP, Ryan, DA. 1998. Otolith and fish size relationships, measurement error, and size selective mortality during the early life of Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 55:1663-1673.

Meekan, MG, Ryan, DAJ, Dodson, JJ, Good, SP. 1998. Does mortality select size or growth potential in young sockeye salmon (*Oncorhynchus nerka*)? A simulation based on otolith - fish size relationships. Canadian Journal of Fisheries and Aquatic Sciences 55:1674-1681.

Meffle, GK. 1992. Techno-arrogance and halfway technologies: salmon hatcheries on the Pacific Coast of North American. Conservation Biology 6:350-354.

Menchen, RS. 1978. A description of California Department of Fish and Game management program for the San Joaquin River system salmon resource. California Department of Fish and Game, Anadromous Fisheries Branch.

Menchen, RS. 1961. The Mokelumne River artificial spawning channel experiment. California Department of Fish and Game, Marine Resources Branch.

Merz, JE, Setka, JD. 2004. Evaluation of a spawning habitat site for Chinook salmon in a regulated California River. North American Journal of Fisheries Management 25:48-56.

Merz, JE. 2001. Association of fall-run chinook salmon redds with woody debris in the lower Mokelumne River, California. California Fish and Game 87:51-60.

Merz, JE. 2001. Diet of juvenile fall-run Chinook salmon in the lower Mokelumne River, California. California Fish and Game 878:102-114.

Merz, JE. 2002. Seasonal feeding habits, growth, and movement of steelhead trout in the lower Mokelumne River, California. California Fish and Game 88:95-111.

Merz, JE. undated. Striped bass predation on juvenile salmonids at the Woodbridge Dam afterbay, Mokelumne

River, California. Lodi, California: East Bay Municipal Utility District. www.delta.dfg.ca.gov/sfrg/docs/MokelumneStriperPredation.pdf

Merz, JE. 1993. A survey of drift and epibenthic communities and their utilization as forage by target fish in the Lower American River, California, February-July , 1992. Sacramento, California: California State University Foundation.

Merz, JE, Merz, WR. 2004. Morphological features used to identify Chinook salmon sex during fish passage. Southwest Naturalist 49:197-202.

Merz, JE, Moyle, PB. 2006. Salmon, wildlife, and wine: marine-derived nutrients in human-dominated ecosystems of Central California. Ecological Applications 16:999-1009.

Merz, JE, Setka, JD. 2004. Evaluation of a spawning habitat enhancement site for Chinook salmon in a regulated California river. North American Journal of Fisheries Management 24:397-407.

Merz, JE, Vanicek, CD. 1996. Comparative feeding habits of juvenile Chinook salmon, steelhead, and Sacramento squawfish in the lower American River, California. California Fish and Game 82:149-159.

Merz, JJ, Setka, JD, Pasternack, GB, Wheaton, JM. 2004. Predicting benefits of spawning -habitat rehabilitation to salmonid (*Oncorhynchus* spp.) fry production in a regulated California river. Canadian Journal of Fisheries and Aquatic Sciences 61:1433-1446.

Mesick, C. 2001a. The effects of San Joaquin River flows and Delta export rates during October on the number of adult San Joaquin chinook salmon that stray. In: Brown, RL, editor. Contributions to the biology of Central Valley salmonids, Fish Bulletin 179. Fish Bulletin.2.California Department of Fish and Game. p. 139-162.

Mesick, C. 2001b. Studies of spawning habitat for fall-run chinook salmon in the Stanislaus River between Goodwin Dam and Riverbank from 1994 to 1997. In: Brown, RL, editor. Contributions to the biology of Central Valley salmonids, Fish Bulletin 179. Fish Bulletin.2. p. 217-252.

Metcalfe, NB, Fraser, NHC, Burns, MD. 1999. Food availability, and the nocturnal vs. diurnal foraging trade-off in juvenile salmon. Journal of Animal Ecology 68:371-381.

Metcalfe, NB, Huntingford, FA, Thorpe, JE. 1988. Feeding intensity, growth rates, and the establishment of life history patterns in juvenile Atlantic salmon *Salmo salar*. Journal of Animal Ecology 57:463-474.

Metcalfe, NB. 1998. The interaction between behavior and physiology in determining life history patterns in Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences 55(Suppl. 1):93-103.

Meyer, KA, Gregory, JS. 2000. Evidence of concealment behavior by adult rainbow trout and brook trout in winter. Ecology of Freshwater Fish 9:138-144.

Miller, JA, Simenstad, CA. 1997. A comparative assessment of a natural and created estuarine slough as rearing habitat for juvenile chinook and coho salmon. Estuaries 20:792-806.

Milligan, CL, Hooke, GB, Johnson, C. 2000. Sustained swimming at low velocity following a bout of exhaustive exercise enhances metabolic recovery in rainbow trout. Journal of Experimental Biology 203:921-926.

Mills, KL. Undated. Comparison of the Central Valley Chinook salmon stock predictor performance. Stinson Beach, California: Point Reyes Bird Observatory .

Mills, TJ, Fisher, F. 1994. Central Valley anadromous sport fish annual run-size, harvest, and population estimates. Sacramento, California: California Department of Fish and Game, Inland Fisheries Division.

Mills, TJ, McEwan, DR, Jennings, MR. 1997. California salmon and steelhead: beyond the crossroads. In: Stouder, DJ, Bisson, PA, Naiman, RJ, editors. Pacific salmon and their ecosystems. New York: Chapman & Hall. p. 91-112.

Milner, NJ, Elliot, JM, Armstrong, JD, Gardiner, R, Welton, JS, Ladle, M. 2003. The natural control of salmon and trout populations in streams. Fisheries Research 62:111-125.

Ministry of Environment, Lands, and Parks (British Columbia). 1997. Ambient water quality criteria for dissolved oxygen. Vancouver:

Minshall, GW, Thomas, SA, Newbold, JD, Monaghan, MT, Cushing, CE. 2000. Physical factors influencing fine organic particle transport and deposition in streams. Journal of the North American Benthological Society 19:1-16.

Modde, T, Hardy, TB. 1992. Influence of different microhabitat criteria on salmonid habitat simulation. Rivers 3:37-44.

Moffett, J. 1949. The first four years of king salmon maintenance below Shasta Dam, Sacramento River, California. California Fish and Game 35:77-102.

Montgomery, DR, Beamer, EM, Pess, GR, Quinn, TP. 1999. Channel type and salmonid spawning distribution and abundance. Canadian Journal of Fisheries and Aquatic Sciences 56:377-387.

Montgomery, DR, Buffington, JM, Peterson, NP, Schuett-Hames, D, Quinn, TP. 1996. Stream-bed scour, egg burial depths, and the influence of salmonid spawning on bed surface mobility and embryo survival. Canadian Journal of Fisheries and Aquatic Sciences 53:1061-1070.

Montgomery, DR, Collins, BD, Buffington, JM, Abbe, TB. 2003. Geomorphic effects of wood in rivers. In: Gregory, SV, Boyer, KL, Gurnell, AM, editors. The ecology and management of wood in world rivers. Bethesda, Maryland: American Fisheries Society. p. 21-48.

Moore, AP, Waring, CP. 1996. Sublethal effects of the pesticide diazinon on olfactory function in mature male Atlantic salmon parr. Journal of Fish Biology 48:758-775.

Moore, TL. 1997. Condition and feeding of juvenile chinook salmon in selected intermittent tributaries of the upper Sacramento River [ms thesis]. California State University, Chico.

Morbrand, LE, Barr, J, Blankenship, L, Campton, DE, Trevor, TPE, Flagg, TA, Mahnken, CVW, Seeb, LW, Seidel, PR, Smoker, WW. 2005. Hatchery reform in Washington state: principles and emerging issues. Fisheries 30:11-23.

Morimoto, RI, Tissieres, A, Georgopoulos, C. 1990. Stress proteins in biology and medicine. Cold Spring Harbor, New York: Cold Spring Harbor Laboratory Press.

Morita, K, Yamamoto, S, Takashima, Y, Matsuishi, T, Kanno, Y, Nishimura, K. 1999. Effect of growth history on egg number and size in wild white-spotted char (*Salvelinus leucomaenis*). Canadian Journal of Fisheries and Aquatic Sciences 56:1585-1589.

Morita, K, Yanamoto, S, Hoshino, N. 2000. Extreme life history change of white-spotted char (*Salvelinus leucomaenis*) after damming. Canadian Journal of Fisheries and Aquatic Sciences 57:1300-1306.

Mote, PW, Parson, EA, Hamleet, AF, Keeton, WS, Lettenmaier, D, Mantua, N, Miles, EL, Peterson, DW, Peterson, DL, Slaughter, R, Snover, AK. 2003. Preparing for climatic change: the water, salmon, and forests of the Pacific Northwest. Climate Change 61:45-88.

Moyle, PB. 1970. Occurrence of king (Chinook) salmon in the Kings River, Fresno County. California Fish and Game 56:314-315.

Moyle, PB, Marchetti, MP, Baldridge, J, Taylor, TL. 1998. Fish health and diversity: justifying flows for a California stream. Fisheries 23:6-15.

Moyle, PB. 1969. Comparative behavior of young brook trout of wild and hatchery origin. Progressive Fish-Culturist 31:51-56.

Moyle, PB. 1994. The decline of anadromous salmonids in California. Conservation Biology 8:869-870.

Moyle, PB. 1977. In defense of sculpins. Fisheries 2:20-23.

Moyle, PB. 2002. Inland Fishes of California. University of California Press.

Moyle, PB, Israel, JA. 2005. Untested assumptions: effectiveness of screening diversions for conservation of fish populations. Fisheries 30:20-28.

Mueter, FJ, Peterman, RM, Pyper, BJ. 2002. Opposite effects of ocean temperature on survival rates of 120 stocks of Pacific salmon (*Oncorhynchus spp.*) in northern and southern areas. Canadian Journal of Fisheries and Aquatic Sciences 59:456-463.

Munch, SB, Kottas, A, Mangel, M. 2005. Bayesian nonparametric analysis of stock-recruitment relationships. Canadian Journal of Fisheries and Aquatic Sciences 62:1808-1821.

Murphy, GI, Shapovalov, L. 1951. A preliminary analysis of northern California salmon and steelhead runs. California Fish and Game 37:497-507.

Murray, CB, Rosenau, ML. 1989. Rearing of juvenile Chinook in nonnatal tributaries of the lower Fraser River. North American Journal of Fisheries Management 118:284-289.

Muscik, JA. 1999. Criteria to define extinction risk in marine fishes. Fisheries 24:6-14.

Myers, JM, Kope, RG, Bryant, GJ, Teel, D, Lierheimer, LJ, Wainwright, TC, Grant, WS, Waknitz, FW, Neely, K, Lindley, ST, Waples, RS. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and

California. U. S. Department of Commerce, National Oceanic and Atmospheric Administration NOAA Technical Memorandum NMFS-NWFSC-35.

Myers, KW, Horton, HF. 1982. Temporal use of an Oregon estuary by hatchery and wild juvenile salmon. In: Kennedy, VS, editor. Estuarine comparisons. New York: Academic Press. p. 388-392.

Myers, KW. 1997. Offshore distribution and migration patterns and ocean survival of salmon. In: Emmett, RL, Scjoeve, MH, editors. Estuarine and ocean survival of Northeastern Pacific salmon: proceedings of the workshop. U. S. Dept. of Commerce. NOAA Technical Memorandum NMFS-NWFSC-29.

Myers, RA, Bowen, KG, Barrowman, NA. 1999. Maximum reproductive rate of fish at low population sizes. Canadian Journal of Fisheries and Aquatic Sciences 56:2404-2419.

Myers, RA, Levin, SA, Lande, R, James, FC, Murdock, WW, Paine, RT. 2004. Hatcheries and endangered salmon. Science 303:1980.

Myrick, CA, Cech, JJJr. 2002. Growth of American River fall-run Chinook salmon in California's Central Valley: temperature and ration effects. California Fish and Game 88:35-44.

Myrick, CA, Cech, JJJr. 2001. Temperature effects on Chinook salmon and steelhead: a review focusing on California's Central Valley populations. http://www.cwemf.org: Bay-Delta Modeling Forum.

Myrick, CA, Cech, JJJr. 2000. Temperature influences on California rainbow trout physiological performance. Fish Physiology and Biochemistry 22:245-254.

Naiman, RJ, Bilby, RE. 1998. River ecology and management. New York: Springer.

National Marine Fisheries Service (NMFS). 1993. Biological opinion for the operation of the federal Central Valley Project and the California State Water Project. Silver Springs, Maryland:

National Marine Fisheries Service (NMFS). 1997. NMFS proposed recovery plan for the Sacramento Rive winter-run Chinook salmon. Long Beach, California:

National Marine Fisheries Service (NMFS). 2000. Predation on salmonids relative to the Columbia River Power System. Seattle, Washington: Northwest Fisheries Science Center. White Paper.

National Research Council (NRC) Committee on Endangered and Threatened Fishes in the Klamath River Basin. 2003. Endangered and threatened fishes in the Klamath River basin: causes of decline and strategies for recovery. Washington, D.C.: National Academies Press.

National Research Council (NRC) Committee on protection and management of Pacific Northwest anadromous salmonids, board on environmental studies and toxicology, commission on life sciences . 1996. Upstream: salmon and society in the Pacific Northwest. National Academy Press.

National Research Council (NRC), Committee on water resources management, instream flows, and salmon survival in the Columbia River Basin. 2004. Managing the Columbia River: instream flows, water withdrawals, and salmon survival . Washington, D. C. : National Academies Press.

Naughton, GP, Bennett, DH, Newman, KB. 2004. Predation on juvenile salmonids by smallmouth bass in the Lower Granite Reservoir system, Snake River. North American Journal of Fisheries Management 24:534-544.

Needham, PR, Hanson, HA, Parker, LP. 1943. Supplementary report on investigations of fish-salvage problems in relation to Shasta Dam. U.S. Fish and Wildlife Service. Special Scientific Report No. 26.

Needham, PR, Smith, OR. 1940. Salmon salvage problems in relation to Shasta Dam, California, and notes on the biology of the Sacramento River salmon. Transactions of the American Fisheries Society 70:55-69.

Needham, PR. 1961. Observations on the natural spawning of eastern brook trout. California Fish and Game 47:27-40.

Neilsen, JD, Geen, GH. 1986. First-year growth of rate of Sixes River chinook salmon as inferred from otoliths: effects of mortality and age at maturity. Transactions of the American Fisheries Society 115:28-33.

Neilson, JD, Geen, GH, Bottom, DL. 1985. Estuarine growth of juvenile chinook salmon (*Oncorhynchus tshawystcha*) as inferred from otolith microstructure. Canadian Journal of Fisheries and Aquatic Sciences 42:899-908.

Neilson, JD, Banford, CE. 1983. Chinook salmon (*Oncorhynchus tshawytscha*) spawner characteristics in relation to redd physical features. Canadian Journal of Zoology 61:1524-1531.

Newman, KB, Buckland, ST, Lindley, ST, Thomas, L, Fernámdez, C. 2006. Hidden process models for animal population dynamics. Ecological Applications 16:74-86.

Newman, KB. 1999. Estimating the chinook salmon production for watersheds within the Sacramento-San Joaquin river system. Moscow, Idaho: University of Idaho, Department of Statistics.

Newman, KB. 2003. Modeling paired release-recovery data in the presence of survival and capture heterogeneity with application to marked juvenile salmon. Statistical Modeling 3:157-177.

Newman, KB, Rice, J. 2002. Modeling the survival of chinook salmon smolts outmigrating through the lower Sacramento River system. Journal of the American Statistical Association 97:983-993.

Nicholas, JW, Hankin, DG. 1988. Chinook salmon populations in Oregon coastal river basins: descriptions of life history and assessment of recent trends in run strength. Portland, Oregon: Oregon Department of Fish and Wildlife. Information Report, Series Number 88-1.

Nichols, FH, Cloern, JE, Luoma, S, Peterson, DH. 1986. The modification of an estuary. Science 231:567-573.

Nichols, K, Foott, JS. 2002. Health monitoring of hatchery and natural fall-run Chinook salmon juveniles in the San Joaquin River and tributaries, April - June 2001. Anderson, California: U.S. Fish and Wildlife Service, California-Nevada Fish Health Center. FY2001 Investigational Report.

Nickleson, T. 2003. The influence of hatchery coho salmon (Oncorhynchus kisutch) on the productivity of wild coho salmon populations in Oregon coastal basins. Canadian Journal of Fisheries and Aquatic Sciences 60:1050-1056.

Nicola, GG, Almodóvar, A. 2004. Growth pattern of stream-dwelling brown trout under contrasting thermal conditions. Transactions of the American Fisheries Society 133:66-78.

Nielsen, JF, Pavey, SA, Wiacek, T, Williams, I. 2005. Genetics of Central Valley *O. mykiss* populations: drainage and watershed scale analyses. San Francisco Estuary and Watershed Science 3:article 1 http://repositories.cdlib.org/mie/sfews/vol3/iss2/art3. http://repositories.cdlib.org/mie/sfews/vol3/iss2/art3

Nielsen, JL. 1995. Evolution and the aquatic ecosystem: defining unique units in population conservation. American Fisheries Society Symposium 17. Bethesda, Maryland:

Nielsen, JL, Pavey, S, Wiacek, T, Sage, GK, Williams, I. 2003. Genetic analyses of Central Valley trout populations 1999-2003. Anchorage, Alaska: USGS Alaska Science Center.

Nielsen, JL, Pavey, SA, Wiacek, T, Williams, I. 2005. Genetics of Central Valley *O. mykiss* populations: drainage and watershed scale analyses. San Francisco Estuary and Watershed Science (online serial) 3: http://repositories.cdlib.org/jmie/sfews/vol3/iss2/art3

Nislow, KH, Einum, S, Foults, CL. 2004. Testing predictions of the critical period for survival concept using experiments with stocked Atlantic salmon. Journal of Fish Biology 65(SA):188-200.

Nislow, KH, Sepulveda, AJ, Folt, CL. 2004. Mechanistic linkage of hydrological regime to summer growth of age-0 Atlantic salmon. Transactions of the American Fisheries Society 133:79-88.

NOAA Fisheries. 2004. Biological opinion on the long-term Central Valley Project and State Water Project operations criteria and plan. National Marine Fisheries Service, Southwest Region.

NOAA Fisheries, West Coast Salmon Biological Review Team (NOAA WCSBRT). 2003. Updated status of federally listed ESUs of West Coast salmon and steelhead. http://santacruz.nmfs.noss.gov/files/pubs/00682.pdf

Noakes, DJ, Beamish, RJ, Sweeting, R, King, J. 2000. Changing the balance: interactions between hatchery and wild Pacific coho salmon in the presence of regime shifts. North Pacific Anadromous Fish Commission Bulletin 2:155-163.

Noble, MA. 2001. Current patterns over the continental shelf and slope. In: Karl, HA, Chin, JL, Ueber, E, Stuaffer, PH, Hendley, JWI, editors. Beyond the Golden Gate -- Oceanography, geology, biology, and environmental issues in the Gulf of the Farallones. USGS Circular 1198.

Northcote, TG. 1984. Mechanisms of fish migration in rivers. In: McCleave, JD, Arnold, GP, Dodson, JJ, Neil, WH, editors. Mechanisms of migration in fishes. New York, N.Y.: Plenum Publishing Company. p. 317-355.

Novartis Crop Protection, Inc. 1997. An ecological risk assessment of diazinon in the Sacramento and San Joaquin river basins. Novartis Crop Protection. Technical Report.

Nugent, J, Hoffarth, P, Brock, W. 2002b. 2002 evaluation of juvenile fall Chinook salmon stranding on the

Hanford Reach of the Columbia River. Washington Department of Fish and Wildlife.

Nugent, J, Newsome, T, Hoffarth, P, Nugent, MBW, Kuklinski, MJr. 2002a. 2001 evaluation of juvenile fall Chinook salmon stranding on the Hanford Reach of the Columbia River. Washington Department of Fish and Wildlife.

O'Keefe, TC, Edwards, RT. 2003. Evidence for hyporheic transfer and removal of marine derived nutrients in a sockeye salmon stream in Southwest Alaska. In: Stockner, J, editor. Nutrients in salmonid ecosystems: sustaining production and biodiversity. American Fisheries Society Symposium. Bethesda, Maryland: American Fisheries Society. p. 99-110.

Oerlemans, J. 2005. Extracting a climate signal from 169 glacier records. Science 308:675-677.

Okihiro, MS, Ostrach, D, Hinton, DE. 1992. American River juvenile Chinook and steelhead histological and morphometric evaluation. School of Veterinary Medicine, University of California. Davis.

Olsén, H. 1999. Present knowledge of kin discrimination in salmonids. Genetica 104:295-299.

Olson, AF, Quinn, TP. 1993. Vertical and horizontal movements of adult chinook salmon *Oncorhynchus tshawytscha* in the Columbia River estuary. Fishery Bulletin 91:171-181.

Olson, PA, Foster, RF. 1957. Temperature tolerances of eggs and young of Columbia River chinook salmon. Transactions of the American Fisheries Society 85:203-207.

Olsén, KH, Petersson, ERB, Lundqvist, H, Järvi, T. 2004. Downstream migration in Atlantic salmon (*Salmo salar*) smolt sibling groups. Canadian Journal of Fisheries and Aquatic Sciences 61:328-331.

Oreskes, N, Belitz, K. 2001. Philosophical issues in model assessment. In: Anderson, MG, Bates, PD, editors. Model validation: perspectives in hydrological science. John Wiley & Sons. p. 23-42.

Oreskes, N, Shrader-Frechette, K, Belitz, K. 1994. Verification, validation, and confirmation of numerical models in the earth sciences. Science 263:641-646.

Oreskes, N. 2004. The scientific consensus on climate change. Science 306:1686.

Orr, M, Crooks, S, Williams, PB. 2003. Will restored tidal marshes be sustainable. San Francisco Estuary and Watershed Science 1:Article 5 http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art5. http://repositories.cdlib.org/jmie/sfews/vol1/iss1/art5

Orsi, JJ. 1999. Report on the 1980-1995 fish, shrimp, and crab sampling in the San Francisco Estuary, California. Technical Report 63. Sacramento, California: The Interagency Ecology Program for the Sacramento-San Joaquin Estuary.

Osenberg, CW, Schmitt, RJ, Holbrook, SJ, Abu-Aba, KE, Flegal, AR. 1994. Detection of environmental impacts; natural variability, effect size, and power analysis. Ecological Applications 4:16-30.

Pacific Fishery Management Council (PFMC). 1984. Final framework agreement for managing the ocean salmon fisheries off the coasts of Washington, Oregon, and California commencing in 1985 . Portland, Oregon:

Pacific Fishery Management Council (PFMC). 2003. Fishery Management Council plan for commercial and recreational salmon fisheries off the coasts of Washington, Oregon, and California as revised through Amendment 14. Portland, Oregon: Pacific Fishery Management Council.

Packman, AI, Bencala, KE. 2000. Modeling surface - subsurface hydrologic interactions. In: Jones, JB, Mulholland, PJ, editors . Streams and ground waters. San Diego, CA: Academic Press. p. 46-82.

Parker, LP, Hanson, HA. 1944. Experiments on transfer of adult salmon into Deer Creek. Journal of Wildlife Management 8:192-197.

Parker, RR, Larkin, PA. 1959. A concept of growth in fishes. Journal of the Fisheries Research Board of Canada 16:721-745.

Pascual, MA, Quinn, TP, Fuss, H. 1995. Factors affecting the homing of fall chinook from Columbia River hatcheries. Transactions of the American Fisheries Society 124:308-320.

Payne, BA, Lapointe, MF. 1997. Channel morphology and lateral stability: effects on distribution of spawning and rearing habitat for Atlantic salmon in a wandering cobble-bed river. Canadian Journal of Fisheries and Aquatic Sciences 54:2627-2636.

Pearcy, WC. 1992. Ocean ecology of North Pacific salmonids. University of Washington Press.

Pearcy, WG, Brodeur, RD, Fisher, JP. 1990. Distribution of juvenile cutthroat trout *Oncorhynchus clarki clarki* and steelhead *O. mykiss* in coastal waters off Oregon and Washington. Fishery Bulletin 88:697-711.

Pearson, TN. 2002. Chronology of ecological interactions associated with the life-span of salmon supplementation programs. Fisheries 27:10-15.

Peck, SL. 2004. Simulation as experiment: a philosophical reassessment for biological modeling. Trends in Ecology and Evolution 19:530-534.

Peery, CA, Bjorn, TC. 2004. Interactions between natural and hatchery chinook salmon parr in a laboratory stream channel. Fisheries Research 66:311-324.

Pennell, W, Barton, BA. 1996. Principles of salmonid culture. Elsevier.

Perry, EA. 1995. Salmon stock restoration and enhancement: strategies and experience in British Columbia. In: Schramm, HLJ, Piper, RG, editors. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium 15. p. 152-160.

Peterman, RM. 1987. Review of the components of recruitment of Pacific salmon. In: Dadswell, MJ, Klauda, RJ, Moffitt, CM, Saunders, RL, Rulllifson, RA, Common strategies of anadromous and catadromous fishes. American Fisheries Society Symposium 1.

Peterson, HH. 1973. Adult returns to date from hatchery-reared one-year old smolts. In: International Atlantic Salmon Foundation , Special Publication 4. p. 219-226.

Peterson, NP, Quinn, TP. 1996. Spatial and temporal variation in dissolved oxygen in natural egg pockets of chum salmon, in Kennedy Creek, Washington. Journal of Fish Biology 48:131-143.

Petersson, E, Järvi, T. 2003. Growth and social interactions of wild and sea-ranched brown trout and their hybrids. Journal of Fish Biology 63:673-686.

Petrusso, PA, Hayes, DB. 2001b. Condition of juvenile Chinook salmon in the upper Sacramento River, California. California Fish and Game 87:19-37.

Petrusso, PA, Hayes, DB. 2001a. Invertebrate drift and feeding habits of juvenile Chinook salmon in the upper Sacramento River, California. California Fish and Game 87:1-18.

Phillips, RW, Claire, EW. 1966. Intragravel movement of the reticulate sculpin, *Cottus perplexus*, and its potential as a predator on salmon embryos. Transactions of the American Fisheries Society 95:210-212.

Pipal, KA. 2005. Summary of monitoring activities for ESA-listed salmonids in California's Central Valley. NOAA-TM-NMFS-SWFSC-373.

Poff, NL, Allan, JD, Bain, MB, Karr, JR, Prestegaard, KL, Richter, BD, Sparks, RE, Stromberg, JC. 1997. The natural flow regime. BioScience 47:769-784.

Pollard, RA. 1955. Measuring seepage through salmon spawning gravel. Journal of the Fisheries Research Board of Canada 12:706-741.

Powell, MJJ, Miller, M. 1990. Shoal spawning by Chinook salmon in Lake Huron. North American Journal of Fisheries Management 10:242-244.

Power, ME, Dietrich, WE, Finlay, JC. 1996. Dams and downstream aquatic biodiversity: potential food web consequences of hydrologic and geomorphic change. Environmental Management 20:887-895.

Power, ME, Dietrich, WE, Sullivan, KO. 2001. Experimentation, observation, and inference in river and watershed investigations. In: Resetarits, WJ, Bernardo, J, editors. Issues and perspectives in experimental ecology. Oxford, U.K.: Oxford University Press. p. 113-132.

Prager, MH, Morh, MS. 2001. The harvest rate model for Klamath fall chinook salmon, with management applications and comments on model development and documentation. North American Journal of Fisheries Management 21:533-547.

Price, CS, Schreck, CB. 2003. Stress and saltwater-entry behavior of juvenile chinook salmon (*Oncorhynchus tshawytscha*): conflicts in physiological motivation. Canadian Journal of Fisheries and Aquatic Sciences 60:910-918.

Puget Sound Technical Recovery Team (PSTRT). 2002. Planning ranges and preliminary guidelines for the delisting and recovery of the Puget Sound Chinook Salmon Evolutionarily Significant Unit . Seattle, Washington: NOAA Fisheries, National Marine Fisheries Service, Northwest Fisheries Science Center.

Punt, AE, Hilborn, R. 1997. Fisheries stock assessment and decision analysis: the Bayesian approach. Reviews in Fish Biology and Fisheries 7:35-63.

Quinn, TJI. 2003. Ruminations on the development and future of population dynamics models in fisheries. Natural

Resources Modeling 16:341-392.

Quinn, TJI, Deriso, RB. 1999. Quantitative Fish Dynamics. Biological Resources Management. New York: Oxford University Press.

Quinn, TP. 2005. The behavior and ecology of Pacific salmon and trout. Bethesda, Maryland: American Fisheries Society.

Quinn, TP. 1990. Current controversies in the study of salmon homing. Ethology Ecology & Evolution 2:49-63.

Quinn, TP. 1980. Evidence for celestial and magnetic compass orientation in lake migrating sockeye salmon. Journal of Comparative Physiology 137:243-248.

Quinn, TP. 1997. Homing, straying, and colonization. In: Grant, WS, editor. Genetic effects of straying of non-native hatchery fish into wild populations: proceedings of the workshop. NOAA Tech Memo . Seattle, Washington: NWFSC, NOAA Tech Memo 30.

Quinn, TP. 1993. A review of homing and straying of wild and hatchery-produced salmon. Fishery Bulletin 18:29-44.

Quinn, TP, Hendry, AP, Wetzel, LA. 1995. The influence of life history trade-offs and the size of incubation gravels on egg size variation in sockeye salmon (*Oncorhynchus nerka*). Oikos 74:425-438.

Quinn, TP, Kinnison, MT, Unwin, MJ. 2001. Evolution of Chinook salmon (*Oncorhynchus tshawystcha*) populations in New Zealand: pattern, rate and process. Genetica 112-113:493-513.

Quinn, TP, Nemeth, RS, McIsacc, DO. 1991. Patterns of homing and straying by fall Chinook salmon in the lower Columbia River Basin. Transactions of the American Fisheries Society 120:150-156.

Quinn, TP, Nielsen, JL, Gan, C, Unwin, MJ, Wilmot, R, Guthrie, C, Utter, FM. 1996. Origin and genetic structure of chinook salmon, *Oncorhynchus tshawytscha*, transplanted from California to New Zealand: allozyme and mtDNA evidence. Fishery Bulletin 94:506-521.

Quinn, TP, Unwin, MJ. 1993. Variation in life history patterns among New Zealand Chinook salmon (*Oncorhynchus tshawytscha*) populations. Canadian Journal of Fisheries and Aquatic Sciences 50:1414-1421.

Quinn, TP, Unwin, MJ, Kinnison, MT. 2000. Evolution of temporal isolation in the wild: genetic divergence in timing of migration and breeding by introduced Chinook salmon populations. Evolution 54:1372-1385.

Quinn, TP, Volk, EC, Hendry, AP. 1999. Natural otolith microstructure patterns reveal precise homing to natal incubation sites by sockeye salmon (*Oncorhynchus nerka*). Canadian Journal of Fisheries and Aquatic Sciences 77:766-775.

Railsback, SF, Stauffer, HB, Harvey, BC. 2003. What can habitat preference models tell us? Tests using a virtual trout population. Ecological Applications 13:1580-1594.

Raleigh, RF. 1971. Innate control of migrations of salmon and trout from natal gravels to rearing areas. Ecology 52:291-297.

Randall, RG, Healey, MC, Dempson, JB. 1987. Variability in length of freshwater residence of salmon, trout, and char . American Fisheries Society Symposium 1.

Rasmussen, C, Ostberg, C, Clifton, DR, Holloway, James L., Rodriquez, RJ. 2003. Identification of a genetic marker that discriminates ocean-type and stream-type chinook salmon in the Columbia River Basin. Transactions of the American Fisheries Society 132:131-142.

Recovery Science Review Panel (RSRP). 2004. Report for the meeting held August 30, September 2, 2004. http://www.nwfsc.noaa.gob/trt/rsrp.cfm: NOAA Fisheries, NWFSC.

Recovery Science Review Panel (RSRP). 2002. Report for the meeting held December 11-13, 2002. http://www.nwfsc.noaa.gob/trt/rsrp.cfm: NOAA Fisheries, NWFSC.

Recovery Science Review Panel (RSRP). 2001. Report for the meeting held March 13-14, 2001. http://www.nwfsc.noaa.gob/trt/rsrp.cfm: NOAA Fisheries, NWFSC.

Recovery Science Review Panel (RSRP). 2000. Report of December 4-6, 2000, meeting. http://www.nwfsc.noaa.gob/trt/rsrp.cfm: NOAA Fisheries, NWFSC. http://www.nwfsc.noaa.gob/trt/rsrp.cfm

Reimers, PE. 1971. The length of residence of juvenile fall Chinook salmon in Sixes River, Oregon. Corvallis, OR: Oregon State University.

Reimers, PE. 1973. The length of residence of juvenile fall chinook salmon in Sixes River, Oregon. Portland: Fish Commission of Oregon. Research Reports of the Fish Commission of Oregon.

Reimers, PE. 1968. Social behavior among juvenile fall Chinook salmon. Journal of the Fisheries Research Board of Canada 25:2005-2008.

Rein, SR. 1993. Model of Chinook salmon population dynamics [dissertation]. University of California Berkeley, Department of Statistics.

Reinhardt, UG. 2001. Selection for surface feeding in farmed and sea-ranched masu salmon juveniles. Transactions of the American Fisheries Society 130:155-158.

Reisenbichler, RR, McIntyre, D, Hallock, RJ. 1982. Relation between size of chinook salmon, *Oncorhynchus tshawytscha*, released at hatcheries and returns to hatcheries and ocean fisheries. California Fish and Game 68:57-59.

Reisenbichler, RR. 1997. Genetic factors contributing to declines of anadromous salmonids in the Pacific Northwest. In: Stouder, DJ, Bisson, PA, Naiman, RJ, Editors. Pacific salmon and their ecosystems. Chapman and Hall. p. 223-244.

Reisenbichler, RR. 1988. Relation between distance transferred from natal stream and recovery rate for hatchery coho salmon. North American Journal of Fisheries Management 8:172-174.

Reisenbichler, RR. 1986. Use of spawner-recruit relations to evaluate the effect of degraded environment and increased fishing on the abundance of fall-run chinook salmon, Oncorhynchus tshawytscha, in several California streams [dissertation]. Seattle: University of Washington.

Reisenbichler, RR, Brown, G. 2003. Potential risks and benefits of hatchery supplementation to naturally spawning populations of salmon. In: MacDonald, AD, Wainwright, TC, editors. Assessing extinction risks for West Coast salmon; NOAA. NOAA Technical Memorandum NMFS-NWFSC-56.

Reisenbichler, RR, McIntyre, JD. 1977. Genetic differences in growth and survival of juvenile hatchery and wild steelhead trout, *Salmo gairdneri*. Journal of the Fisheries Research Board of Canada 34:123-128.

Reisenbichler, RR, McIntyre, JD, Solazzi, MF, Landing, SW. 1992. Genetic variation in steelhead of Oregon and Northern California. Transactions of the American Fisheries Society 121:158-169.

Reisenbichler, RR, Rubin, SP. 1999. Genetic changes from artificial propagation of Pacific salmon affect the productivity and viability of supplemented populations . ICES Journal of Marine Science 56:459-466.

Reiser, DW, White, RG. 1990. Effects of streamflow reduction on chinook salmon egg incubation and fry quality. Rivers 1:110-118.

Rempel, L, Church, M. 2002. Morphological and habitat classification of the lower Fraser River gravel-bed reach: confirmation and testing. Vancouver, British Columbia: Department of Geography, University of British Columbia.

Rennie, CD, Millar, RG. 2000. Spatial variability of stream bed scour and fill: a comparison of scour depth in chum salmon (*Oncorhynchus keta*) redds and adjacent bed. Canadian Journal of Fisheries and Aquatic Sciences 57:928-938.

Rennie, CD, Miller, RG. 2000. Spatial variability of stream bed scour and fill: a comparison of scour depth in chum salmon (*Oncorhynchus keta*) redds and adjacent bed. Canadian Journal of Fisheries and Aquatic Sciences 57:928-938.

Resources Agency of California. 1964. The effect of water development on the Delta environment. Sacramento: Resources Agency of California. Delta fish and wildlife protection study, report no. 3.

Reynolds, FL, Mills, TJ, Benthin, R, Low, A. 1993. Restoring Central Valley steams: a plan for action. Sacramento, California: California Department of Fish and Game.

Rice, C, Beamer, E, Lomax, D, Henderson, R, Pess, G. 2003. Distribution and abundance of hatchery and wild juvenile chinook salmon in nearshore waters of Skagit Bay, Puget Sound, Washington. Program, 2003 Georgia Basin/Puget Sound Research Conference. www.psat/wa/gov/Publications/2003research/rc03_abstracts/oral_sessions/session_5c

Rich, AA. 1987. Report on studies conducted by Sacramento County to determine the temperatures which optimize growth and survival in juvenile Chinook salmon (*Oncorhynchus tshawystcha*). Sacramento, California: McDonough, Holland & Allen.

Rich, WH. 1920. Early history and seaward migration of chinook salmon in the Columbia and Sacramento Rivers. Bulletin of the Bureau of Fisheries 37:3-77.

Rich, WH. 1925. Growth and degree of maturity of chinook salmon in the ocean. Bulletin of the Bureau of

Fisheries 41:15-90.

Rich, WH, 1939. Local populations and migration in relation to the conservation of Pacific salmon in the western states and Alaska. In: Moulton, FR, editor. The migration and conservation of salmon. p. 45-50.

Rich, WH. 21. The relative maturity of the chinook salmon taken in the ocean along the Pacific Coast.

Rich, WH, Holmes, HB. 1928. Experiments in marking young chinook salmon on the Columbia River, 1916 to 1927. Bulletin of the Bureau of Fisheries 44:

Richards, J, Olsen, D. 1993. Inter-basins comparison study: Columbia River salmon production compared to other West Coast production areas. Phase 1 analysis for U. S. Army Corps of Engineers.

Ricker, WE. 1980. Causes of the decrease in age and size of Chinook salmon. Canadian Technical Report of Fisheries and Aquatic Sciences.

Ricker, WE. 1981. Changes in average size and age of Pacific salmon. Canadian Journal of Fisheries and Aquatic Sciences 38:1636-1656.

Ricker, WE. 1975. Computation and interpretation of biological statistics of fish populations. Fisheries Research Board of Canada, Bulletin No. 191.

Ricker, WE. 1972. Hereditary and environmental factors affecting certain salmonid populations. In: Simon, RC, Larkin, PA, editors. The stock concept in Pacific salmon. H. R. MacMillian Lectures in Fisheries. Vancouver: University of British Columbia. p. 19-160.

Ricker, WE. 1973. Two mechanisms that make it impossible to maintain peak-period yields from stocks of Pacific salmon and other fishes. Journal of the Fisheries Research Board of Canada 30:1275-1286.

Ricker, WO. 1960. The effect of environmental factors and heredity on the morphology and behavior of the Pacific salmon. VNIRO, Nauchnaya Informatsiya 4:1-12.

Riddell, BE. 1986. Assessment of selective fishing on the age at maturity in Atlantic salmon (*Salmo salar* ): a genetic perspective. In: Meerburg, DJ, editor. Salmonid age at maturity. Canadian Special Publication in Fisheries and Aquatic Sciences 89; p. 102-109.

Riddell, BE. 1993. Spatial organization of Pacific salmon: what to conserve? In: Cloud, JG, Thorgaard, GH, editors. Genetic conservation of salmonid fishes. New York: Plenum Press. p. 22-41.

Rieman, BE, Dunham, JB. 2000. Metapopulations and salmonids: a synthesis of life history patterns and empirical observations. Ecology of Freshwater Fish 9:51-64.

Rieman, BE, Beamesderfer, RC, Vigg, S, Poe, TP. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458.

Riley, SC, Fuss, HJ, LeClair, LL. 2004. Ecological effects of hatchery-reared juvenile Chinook and coho salmon on wild juvenile salmonids in two Washington streams. North American Journal of Fisheries Management 4:506-517.

Rise, ML, von Schalburg, D, Brown, GD, Mawer, MA, Devlin, RH, Kuipers, N, Busby, M, Beetz-Sargent, M, Alberto, R, Bobbs. A. Ross, Hunt, P, Shukin, R, Zeznik, JA, Nelson, C, Jones, SRM, Smailus, DE, Jones, SJM, Schein, JE, Marra, MA, Butterfield, YSN, Stott, JM, Ng, SHS, Davidson, WS, Koop, BF. 2004. Development and application of a salmonid EST database and cDNA microarray: data mining and interspecific hybridization characteristics. Genome Research 13:478-490.

Rombough, PJ. 1988. Growth, aerobic metabolism, and dissolved oxygen requirements of embryos and alevins of steelhead, *Salmo gairdneri*. Canadian Journal of Zoology 66:651-660.

Rombough, PJ. 1985. Initial egg weight, time to maximum alevin wet weight, and optimal ponding times for chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 42:287-291.

Rombough, PJ. 1986. Mathematical model for predicting the dissolved oxygen requirements of steelhead (Salmo gairdneri) embryos and alevins in hatchery incubators. Aquaculture 59:119-137.

Rondorf, DW, Dutchuk, MS, Kolok, AS, Gross, ML. 1985. Bioenergetics of juvenile salmon during the spring migration. Bonneville Power Administration. Annual Report 1983 (Contract DE-A179-82BP35346).

Roni, P, Quinn, TP. 1995. Geographic variation in size and age of North American Chinook salmon. North American Journal of Fisheries Management 15:325-345.

Roos, M. 1991. A trend of decreasing snowmelt runoff in California. Proceedings of the 59th Western Snow

Conference; Juneau, Alaska. p. 29-36.

Roper, B, Scarnecchia, DL. 1996. A comparison of trap efficiencies for wild and hatchery ago-0 Chinook salmon. North American Journal of Fisheries Management 16:214-217.

Roper, BB, Scarnecchia, DL, La Marr, TJ. 1994. Summer distribution of and habitat use by Chinook salmon and steelhead with a major basin of the South Umpqua River, Oregon. Transactions of the American Fisheries Society 123:298-308.

Rosenfeld, JS, Boss, S. 2001. Fitness consequences of habitat use for juvenile cutthroat trout: energetic costs and benefits in pools and riffles.

Ruggerone, GT. 2000. Differential survival of juvenile sockeye and coho salmon exposed to low dissolved oxygen during winter. Journal of Fish Biology 56:1013-1016.

Rutter, C. 1909. The fishes of the Sacramento-San Joaquin Basin, with a study of their distribution and variation. Bulletin of the United States Fish Commission 27:103-152.

Rutter, C. 1904. Natural history of the Quinnat Salmon. Bulletin of the United States Fish Commission 22:65-142.

Ryan, BA, Smith, SG, Butzerin, JM, Ferguson, JW. 2003. Relative vulnerability to avian predation of juvenile salmonids tagged with passive integrated transponders in the Columbia River estuary. Transactions of the American Fisheries Society 132:275-288.

Sacramento River Conservation Area Forum (SRCAF). 2003. Handbook. http://www.sacramentoriver.ca.gov/publications/handbook/handbook.html. (as of 1/05)

Sacramento River Fall Chinook Review Team (SRFCRT). 1994. Sacramento River Fall Chinook Review Team Report. Portland, Oregon: Pacific Fishery Management Council.

Sacramento San-Joaquin Estuary Fishery Resource Office (SSJEFRO ). 2003. Abundance and survival of juvenile chinook salmon in the Sacramento-San Joaquin Estuary. Stockton, California: U.S. Fish and Wildlife Service.

Saiki, MK, Castleberry, DT, May, TW, Martin, BA, Bullard, FN. 1995. Copper, cadmium, and zinc concentrations in aquatic food chains from the upper Sacramento River (California) and selected tributaries. Archives of Environmental Contamination and Toxicology 29:484-491.

Salo, EO. 1991. Life history of chum salmon (*Oncorhynchus keta*). In: Groot, C, Margolis, L, editors. Pacific salmon life histories. Vancouver, British Columbia: UCB Press. p. 231-310.

Salo, EO. 1960. Report on Butte Creek investigations, July 27 - August 3, 1960. Arcata, California: Humboldt State College, Division of Natural Resources.

San Joaquin River Group Authority. 2004. 2003 Annual Technical Report. Modesto, California:

San Joaquin River Group Authority. 2005. 2004 Annual Technical Report. Modesto, California:

Sandahl, JF, Baldwin, DH, Jenkins, JJ, Scholz, NL. 2004. Odor-evoked field potentials as indicators of sublethal neurotoxicity in juvenile coho salmon (*Oncorhynchus kisutch*) exposed to copper, chlorpyrifos, or esfenvalerate. Canadian Journal of Fisheries and Aquatic Sciences 61:404-413.

Sandercock, FK. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). In: Groot, C, Margolis, L, editors. Pacific salmon life histories. Vancouver, British Columbia: UCB Press. p. 395-446.

Sasaki, S. 1966. Distribution and food habits of king salmon, *Oncorhynchus tshawytscha*, and steelhead rainbow trout, *salmo gairdnerii*, in the Sacramento-San Joaquin delta. In: Turner, JL, Kelley, DW, compilers. Ecological studies of the Sacramento-San Joaquin delta, part II. Fish Bulletin 136.California Department of Fish and Game. p. 108-114.

Savereide, JW, Quinn, TJ. 2004. An age-structured assessment model for Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 61:974-985.

Schaefer, MB. 1951. Estimation of the size of animal populations by marking experiments. U. S. Fish and Wildlife Service Bulletin 52:189-203.

Schaffter, RG. 1980. Fish occurrence, size, and distribution in the Sacramento River near Hood, California during 1973 and 1974. California Department of Fish and Game. Anadromous Fisheries Branch Administrative Report.

Schaffter. R. G., Jones, PA, Karlton, JG. 1983. Sacramento River and tributaries bank protection and erosion control investigation - evaluation of impacts on fisheries: final report. Stockton, California: California Department of Fish and Game.

Scheuerell, MD, Williams, JG. 2005. Forecasting climate-induced changes in the survival of Snake River spring/summer Chinook salmon (*Oncorhynchus tshawytscha*). Fisheries Oceanography 14:448-457.

Scheurell, MD. 2005. Influence of juvenile size on the age at maturity of individually marked wild Chinook salmon. Transactions of the American Fisheries Society 134:999-1004.

Schindler, DE, Scheuerell, MD, Moore, JW, Gende, SM, Francis, TB, Palen, WJ. 2003. Pacific salmon and the ecology of coastal ecosystems. Frontiers in Ecology and the Environment 1:31-37.

Schlosser, IJ. 1991. Stream fish ecology: a landscape perspective. BioScience 41:704-712.

Schmitt, RJ, Osenberg, CW. 1996. Detecting ecological impacts. Editors. _San Diego: Academic Press.

Schnute, J. 1985. A general theory for analysis of catch and effort data. Canadian Journal of Fisheries and Aquatic Sciences 42:414-429.

Schnute, JT. 2003. Designing fishery models: a personal adventure. Natural Resources Modeling 16:393-413.

Schnute, JT, Haigh, R. 2003. A simulation model for designing groundfish trawl surveys. Canadian Journal of Fisheries and Aquatic Sciences 60:640-656.

Schnute, JT, Kronlund, AR. 2002. Estimating salmon stock-recruitment relationships from catch and escapement data. Canadian Journal of Fisheries and Aquatic Sciences 59:433-449.

Schnute, JT, Richards, LJ. 2001. Use and abuse of fishery models. Canadian Journal of Fisheries and Aquatic Sciences 58:10-17.

Scholz, NL, Truelove, NK, French, BL, Berejikian, BA, Quinn, TP, Casillas, E, Collier, TC. 2000. Diazinon disrupts antipredator and homing behaviors in chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 57:1911-1918.

Schrank, AJ, Rahel, FJ, Johnstone, HC. 2003. Evaluating laboratory-derived thermal criteria in the field: an example involving Bonneville cutthroat trout. Transactions of the American Fisheries Society 132:100-109.

Schreck, CB. 1981. Parr-smolt transformation and behavior. In: Brannon, EL, Salo, EO, editors. Salmon and trout migratory behavior symposium; Seattle, Washington : University of Washington, School of Fisheries.

Schrock, RM, Beeman, JW, Rondorf, DW, Haner, PV. 1994. A microassay for gill sodium, potassium-activated ATPase in juvenile Pacific salmonids. Transactions of the American Fisheries Society 123:223-229.

Schuett-Hames, DE, Peterson, NP, Conrad, R, Quinn, TP. 2000. Patterns of gravel scour and fill after spawning by chum salmon in a Western Washington stream. North American Journal of Fisheries Management 20:610-617.

Schumm, SA. 1977. Drainage Basin Morphology. Benchmark Papers in Geology 41. New York: Halstead Press.

Scofield, N. 29. The status of salmon in California. California Fish and Game 15:13-18.

Scofield, NB. 1913. A general report on a quinnat salmon investigation, carried on during the spring and summer of 1911. Fish Bulletin 1:35-41.

Scofield, WL. 1920. King salmon marking experiment at Klamath River, 1919. California Fish and Game 6:101-103.

Scott, D, Shirvell, CS. 1987. A critique of the Instream Flow Incremental Methodology and observations of flow determinations in New Zealand. In: Craig, JF, Kemper, JB, Editors. Regulated streams: advances in ecology. New York: Plenum Press.

Seber, GA. 1982. The estimation of animal abundance and related parameters. New York: MacMillian.

Secor, DH. 1992. Application of otolith microchemistry analysis to investigate anadromy in Chesapeake Bay striped bass *Morone saxatilus*. Fishery Bulletin 90:798-806.

Sedell, JR, Reeves, GH, Hauer, RF, Stanford, JA, Hawkins, CP. 1990. Role of refugia in recovery from disturbances: modern fragmented and disconnected river systems. Environmental Management 14:711-724.

Shackley, PE, Talbot, C, Cowan, A. 1993. The use of whole-body sodium, potassium and calcium content to identify the nutrient status of first year salmon fry. Journal of Fish Biology 43:825-836.

Shapovalov, L. 1967. Biology and management of steelhead trout in California. California Department of Fish and Game. Inland Fisheries Administrative Report.

Shapovalov, L. 1937. Experiments in hatching steelhead eggs in gravel. California Fish and Game 23:208-214.

Shapovalov, L. 1947. Report on fisheries resources in connection with the proposed Yolo-Solano Development of the United States Bureau of Reclamation. California Fish and Game 33:61-88.

Shapovalov, L, Taft, AC. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and Silver Salmon (*Oncorhynchus kisutch*). Sacramento: California Department of Fish and Game. Fish Bulletin No. 98.

Shaw, PA, Maga, JA. 1943. The effect of mining silt on the yield of fry from salmon spawning beds. California Fish and Game 29:29-41.

Shedlock, AM, Parker, JD, Crispin, DA, Pietsch, TW, Burmer, GC. 1992. Evolution of the salmonid mitochondrial control region. Molecular Phylogenetics and Evolution 1:179-192.

Shelbourn, JE, Clarke, WC, Levings, CD. 1995. Effect of lowered temperature on growth of juvenile Nechako River Chinook salmon (*Oncorhynchus tshawytscha*) at three ration levels. Canadian Data Report of Fisheries and Aquatic Sciences.

Shelton, JM, Pollock, RD. 66. Siltation and egg survival in incubation channels.

Shepherd, JG. 1982. A versatile new stock-recruitment relationship for fisheries and the construction of sustainable yield curves. Journal du conseil. conseil permanent international pour l'exploration de a\la mer 21:

Sheridan, WL. 1962. Waterflow through a salmon spawning riffle in Southeastern Alaska. United States Fish and Wildlife Service Special Report -- Fisheries No. 407.

Shirvell, CS. 1989. Ability of PHABSIM to predict chinook salmon spawning habitat. Regulated Rivers: Research and Management 3:277-289.

Shirvell, CS. 1994. Effect of changes in stream flow on the microhabitat use and movements of sympatric juvenile coho salmon (*Oncorhynchus kisutch*) and Chinook salmon (*O. tshawytscha*) in a natural stream. Canadian Journal of Fisheries and Aquatic Sciences 51:1644-1652.

Shirvell, CS. 1986. Pitfalls of physical habitat simulation in the Instream Flow Incremental Methodology. Prince Rupert, British Columbia: Department of Fisheries and Oceans, Fisheries Research Branch. Canadian Technical Report of Fisheries and Aquatic Sciences.

Sholes, WH, Hallock, RJ. 1979. An evaluation of rearing fall-run chinook salmon, *Oncorhynchus tshawytscha*, to yearling at Feather River Hatchery, with a comparison of returns from hatchery and downstream releases . California Fish and Game 65:239-255.

Shreffler, DK, Simenstad, CA, Thom, RM. 1992. Foraging by juvenile salmon in a restored estuarine wetland. Estuaries 15:204-213.

Shumway, DL, Warren, CE, Doudoroff, P. 1964. Influence of oxygen concentration and water movement on growth of steelhead trout and coho salmon embryos. Transactions of the American Fisheries Society 93:342-356.

Silver, SJ, Warren, CE, Doudoroff, P. 1963. Dissolved oxygen requirements of developing steelhead trout and chinook salmon embryos and different water velocities. Transactions of the American Fisheries Society 92:327-343.

Simenstad, CA, Eggers, DM. 1981. Juvenile salmonid and baitfish distribution, abundance, and prey resources in selected areas of Grays Harbor, Washington. Seattle, Washington: University of Washington, Fisheries Research Institute. FRI-UW-8116.

Simenstad, CA, Fresh, KL, Salo, EO. 1982. Role of Puget Sound and Washington coastal estuaries in the life histories of Pacific salmon: an unappreciated function . In: Kennedy, VS, editor. Estuarine Comparisons. New York: Academic Press. p. 343-364.

Simpkins, DG, Hubert, WA, Martinez del Rio, C, Rule, DC. 2003. Effect of swimming activity on relative weight and body composition of juvenile rainbow trout. North American Journal of Fisheries Management 23:283-289.

Smith, BD, Ward, BR. 2000. Trends in wild adult steelhead (*Oncorhynchus mykiss*) abundance for coastal regions of British Columbia support the variable marine survival hypothesis. Canadian Journal of Fisheries and Aquatic Sciences 57:271-284.

Skinner, JE. 1972. Ecological studies of the Sacramento-San Joaquin estuary. Delta Fish and Wildlife Protection Study. Sacramento : California Department of Fish and Game.

Skinner, JE. 1962. Fish and wildlife resources of the San Francisco Bay Area. Sacramento, California: California Department of Fish and Game.

Skinner, JE. 1958. Some observations regarding the king salmon runs of the Central Valley. Sacramento,

California: California Department of Fish and Game.

Slater, DW. 1963. Winter-run chinook salmon in the Sacramento River, California with notes on water temperature requirements at spawning. U. S. Fish and Wildlife Service.

Smith, AK. 1973. Development and application of spawning velocity and depth criteria for Oregon salmonids. Transactions of the American Fisheries Society 102:312-316.

Smith, BD, Ward, BR. 2000. Trends in wild adult steelhead (*Oncorhynchus mykiss*) abundance for coastal regions of British Columbia support the variable marine survival hypothesis. Canadian Journal of Fisheries and Aquatic Sciences 57:271-284.

Smith, CC, Fretwell, SD. 1974. The optimal balance between size and number of offspring. The American Naturalist 108:499-506.

Smith, GR. 1992. Introgression in fishes: significance for paleontology, cladistics, and evolutionary rates. Systematic Biology 41:41-57.

Smith, GR, Stearley, RF. 1989. The classification and scientific names on rainbow and cutthroat trouts. Fisheries 14:4-10.

Smith, RJF. 1985. The control of fish migration. Berlin: Springer-Verlag.

Smith, TR, Buckley, LJ. 2003. RNA-DNA ratio in scales from juvenile cod provides a nonlethal measure of feeding condition. Transactions of the American Fisheries Society 132:9-17.

Snider, B, Reavis, B, Hill, S. 1998. Upper Sacramento River late fall-run Chinook salmon escapement survey, December 1997-May 1998. Sacramento: California Department of Fish and Game, Environmental Services Division.

Snider, B, Reavis, B, Hill, S. 1999. Upper Sacramento River late fall-run Chinook salmon escapement survey, December 1998-May 1999. Sacramento: California Department of Fish and Game, Environmental Services Division.

Snider, B, Reavis, B, Hill, S. 2000. Upper Sacramento River late fall-run Chinook salmon escapement survey, December 1999-April 2000. Sacramento: California Department of Fish and Game, Habitat Conservation Division.

Snider, B, Titus, R. 1998. Evaluation of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, November 1995-July 1996. California Department of Fish and Game, Stream Evaluation Program. Technical Report.

Snider, B, Titus, RG. 2001. Lower American River emigration survey, October 1997-September 1998 . Sacramento, CA: California Department of Fish and Game, Stream Evaluation Unit. Technical Report No. 01-6.

Snider, B, Titus, RG. 2002. Lower American River emigration survey, October 1999-September 2000 . Sacramento, CA: California Department of Fish and Game, Stream Evaluation Unit. Technical Report No. 02-4.

Snider, B, Titus, RG. 2000a. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1996 - September 1997. Sacramento, California: California Department of Fish and Game, Habitat Conservation Division.

Snider, B, Titus, RG. 2000b. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1997 - September 1998. Sacramento, California: California Department of Fish and Game, Habitat Conservation Division.

Snider, B, Titus, RG. 2000c. Timing, composition and abundance of juvenile anadromous salmonid emigration in the Sacramento River near Knights Landing, October 1998 - September 1999. Sacramento, California: California Department of Fish and Game, Habitat Conservation Division.

Snider, B, Vyverberg, K. 1996. Chinook salmon redd survey, lower American River, fall 1995. Sacramento, CA: California Department of Fish and Game, Stream flow and Habitat Evaluation Program.

Snowden, TK, Power, G. 1985. Prediction of rainbow trout embryo survival in relation to groundwater seepage and particle size of spawning substrates. Transactions of the American Fisheries Society 114:804-812.

Snyder, JO. 1924c. An experiment relating to the homing instinct of the king salmon. California Fish and Game 10:8-64.

Snyder, JO. 1922. The return of marked salmon grilse. California Fish and Game 8:103-107.

Snyder, JO. 1928. Salmon Investigation. California Fish and Game 14:25-29.

Snyder, JO. 1931. Tagging and marking. Report from California Department of Fish and Game. Proceedings, 1930 Annual Meeting of the International Pacific Salmon Federation; Stanford University, Palo Alto, California.

Snyder, JO. 1924a. Third report on return of king salmon marked in 1919 in the Klamath River. California Fish and Game 10:110.

Snyder, JO. 1921. Three California marked salmon recovered. California Fish and Game 7:1-5.

Snyder, JO. 1924b. Young salmon taken at sea. California Fish and Game 10:63-64.

Snyder, JO. 1931. Salmon of the Klamath River, California. Sacramento, California: Division of Fish and Game of California. Fish Bulletin No. 34.

Sommer, TR, Nobroga, ML, Harrell, WC, Batham, W, Kimmerer, WJ. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58:325-333.

Sommer, TR, Harrell, WC, Mueller Solger, A, Tom, B, Kimmerer, W. 2004. Effects of flow variation on channel and floodplain biota and habitats of the Sacramento River, California, USA. Aquatic Conservation: Marine and Freshwater Ecosystems 14:247-261.

Sommer, TR, Harrell, WC, Nobriga, M. 2005. Habitat use and stranding risk of juvenile Chinook salmon on a seasonal floodplain. North American Journal of Fisheries Management 25:1493-1504.

Sophocleous, M. 2002. Interactions between groundwater and surface water: the state of the science. Hydrogeology Journal 10:52-67.

Soulsby, C, Malcolm, IA, Youngson, AF. 2001. Hydrogeochemistry of the hyporheic zone in salmon spawning gravels: a preliminary assessment in a degraded agricultural stream. Regulated Rivers: Research and Management 17:651-665.

Sowden, TK, Power, G. 1985. Prediction of rainbow trout embryo survival in relation to groundwater seepage and particle size of spawning substrate. Transactions of the American Fisheries Society 114:804-812.

Speed, T. 1993. Modeling and managing a salmon population. In: Barnett, V, Turkman, KF, editors. Statistics for the Environment. John Wiley & Sons. p. 265-290.

Stanford, JA, Ward, JV. 1998. The hyporheic habitat of river ecosystems. Nature 335:64-66.

Stanislaus River Fish Group. 2004. A summary of fisheries research in the lower Stanislaus River: working draft.

Starfield, AM. 1997. A pragmatic approach to modeling for wildlife management. Journal of Wildlife Management 61:261-270.

Stauffer, GD. 1973. A growth model for salmonids reared in hatchery environments [dissertation]. Seattle: University of Washington, Department of Zoology.

Stearley, RF, .Smith, GR. 1993. Phylogeny of the Pacific trouts and salmons (*Oncorhynchus*) and genera of the family Salmonidae. Transactions of the American Fisheries Society 122:1-33.

Stearns, SC, Hendry, AP. 2004. The salmonid contribution to key issues in evolution. Evolution illuminated: salmon and their relatives. New York: Oxford University Press.

Steen, RP, Quinn, TP. 1999. Egg burial depth by sockeye salmon (*Oncorhynchus nerka*): implications for survival of embryos and natural selection on female body size. Canadian Journal of Zoology 77:836-841.

Stefansson, SO, Björnsson, BTH, Sundell, K, Nyhammer, G, McCormick, SD. 2003. Physiological characteristics of wild Atlantic salmon post-smolts during estuarine and coastal migration. Journal of Fish Biology 63:942.

Steidl, RJ, Hayes, JP, Schauber, E. 1997. Statistical power analysis in wildlife research. Journal of Wildlife Management 61:270-279.

Stevens, DE. 1966. Distribution and food habits of the American shad (*Alsoa sapidissima*) in the Sacramento-San Joaquin Delta. In: Turner, JL, Kelley, DW, Editors. Ecological studies of the Sacramento-San Joaquin Delta, Part II. Fish Bulletin 136.

Stevens, DE, Miller, LW. 1983. Effects of river flow on abundance of young Chinook salmon, American shad, longfin smelt, and delta smelt in the Sacramento-San Joaquin River system. North American Journal of Fisheries Management 3:425-437.

Steward, CR, Bjorn, TC. 1990. Supplementation of salmon and steelhead stocks with hatchery fish: a synthesis of published literature. Portland, Oregon: Bonneville Power Administration.

Stewart, IJ, Marison, SM, Boatright, CP, Buck, GB, Quinn, TP. 2004. Site fidelity of spawning sockeye salmon (*Oncorhynchus nerka* W.) in the presence and absence of olfactory cues. Ecology of Freshwater Fish 13:104-110.

Stewart-Oaten, A. 1996. Goals in environmental monitoring. In: Schmitt, RJ, Osenberg, CW, editors. Detecting ecological impacts. San Diego: Academic Press. p. 17-28.

Stillwater Sciences. 2004. Lower Calaveras River Chinook salmon and steelhead limiting factor analysis, first year report (revised). Stillwater Sciences, Berkeley, California.

Stillwater Sciences. 2001. Merced River Restoration Baseline Studies. Berkeley, CA: Stillwater Science.

Stine, S. 1994. Extreme and persistent drought in California and Patagonia during mediaeval time. Nature 369:546-549.

Stockner, J. 2003. Nutrients in salmonid ecosystems: sustaining production and biodiversity, American Fisheries Society Symposium 34. Bethesda, Maryland: American Fisheries Society.

Stockwell, CA, Hendry, AP, Kinnison, MT. 2003. Contemporary evolution meets conservation biology. Trends in Ecology and Evolution 18:94-101.

Stone, L. 18876. Report on operations during 1874 at the United States salmon hatching establishment on the McCloud River, California. Washington, D.C.: U.S. Commission of Fisheries. Report of the Commissioner for 1873-4 and 1874-5. Appendix 22:437-478.

Storber, QJ, Walden, SJ, Griggs, DT. 1973. Juvenile salmonid migration through Skagit Bay. In: Storber, QJ, Salo, EO, editors. Ecological studies of the proposed Kilet Island nuclear power site. Seattle, Washington: University of Washington, Fisheries Research Institute. p. 35-70.

Stouder, DJ, Bisson, PB, Naiman, RJ. 1997. Pacific salmon and their ecosystems. New York: Chapman & Hall.

Stuart, TA. 1954. Spawning sites of trout. Nature 173:354.

Sullivan, K, Martin, DJ, Cardwell, RD, Toll, JE, Duke, S. 2000. An analysis of the effect of temperature on salmonids of the Pacific northwest with implications for selecting temperature criteria. Portland, Oregon: Sustainable Ecosystems Institute.

Sumner, FH, Smith, OR. 1940. Hydraulic mining and debris dams in relation to fish life in the American and Yuba rivers of California. California Fish and Game 26:2-22.

Sutton, SG, Built, TP, Jaedrocj. Richard L. 2000. Relationships among fat weight, body weight, water weight, and condition factor in wild Atlantic salmon parr. Transactions of the American Fisheries Society 129:527-538.

Swan, GA. 1989. Chinook salmon spawning surveys in deep waters of a large, regulated river . Regulated Rivers: Research and Management 4:355-370.

Swanson, C, Young, PS, Cech, JJJr. 2004. Swimming in two-vector flows: performance and behavior of juvenile Chinook salmon near a simulated screed water diversion. Transactions of the American Fisheries Society 133:265-278.

Sweeting, RM, Beamish, RJ, Noakes, DJ, Neville, CM. 2003. Replacement of wild coho salmon by hatchery-reared coho salmon in the Strait of Georgia of the past three decades. North American Journal of Fisheries Management 23:492-502.

Tabor, RA, Shivley, R. S., Poe, TP. 1993. Predation on juvenile salmonids by smallmouth bass and northern squawfish in the Columbia River near Richland, Washington. North American Journal of Fisheries Management 13:831-838.

Taft, AC, Shapovalov, L. 1938. Homing instinct and straying among steelhead trout (*Salmo gairdnerii*) and silver salmon (*Oncorhynchus kisutch*). California Fish and Game 24:118-125.

Tait, JS. 1960. The first filling of the swim bladder in salmonids. Canadian Journal of Zoology 38:179-187.

Tallman, RF, Healey, MC. 1994. Phenotypic differentiation in seasonal ecotypes of chum salmon, *Oncorhynchus keta*. Canadian Journal of Fisheries and Aquatic Sciences 48:661-671.

Tappel, PD, Bjornn, TC. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123-135.

Taylor, EB. 1998. Adaptive variation in rheotactic and agonistic behavior in newly emerged fry of Chinook

salmon, *Oncorhynchus tshawytscha*, from ocean- and stream-type populations. Canadian Journal of Fisheries and Aquatic Sciences 45:237-243.

Taylor, EB. 1997. Local adaptation. In: Grant, WS, editor. Genetic effects of straying of non-native hatchery fish into wild populations: proceedings of the workshop. NOAA Technical Memorandum NMFS NWFSC 30.

Taylor, EB. 1991. A review of local adaptation in Salmonidae, with particular reference to Pacific and Atlantic salmon. Aquaculture 98:185-207.

Teel, DJ, Milner, GB, Winans, GA, Grant, WS. 2000. Genetic population structure and origin of life history types in chinook salmon in British Columbia, Canada. Transactions of the American Fisheries Society 129:194-209.

Terhune, LDB. 1958. The Mark VI groundwater standpipe for measuring seepage through salmon spawning gravel. Journal of the Fisheries Research Board of Canada 15:1027-1063.

Thomas, AE, Banks, JL, Greenland, DC. 1969. Effect of yolk sac absorption on the swimming ability of fall Chinook salmon. Transactions of the American Fisheries Society 89:406-410.

Thomas, CD, Cameron, A, Green, RE, Bakkenes, M, Beaumont, LJ, Collingham, Y, Erasmus, BFN, Ferreira de Siqueira, M, Grainger, A, Hannah, L, Hughes, L, Huntley, B, van Jaarsveld, AS, Midgley, GF, Miles, L, Ortega-Huerta, Peterson, AT, Phillips, OL, Williams, SE. 2004. Extinction risk from climate change. Nature 427:145-148.

Thomas R. Payne & Associates. 2002. Evaluation of project effects on instream flows and fish habitat. Arcata, California: Oroville Facilities Relicensing (Project No. 2100), SP-F16.

Thompson, WF. 1919. The conservation of our fisheries. California Fish and Game 51:49-59.

Thorpe, JE. 1977. bimodal distribution of lengths of juvenile Atlantic salmon (*Salmo salar* L.) under artificial rearing conditions. Journal of Fish Biology 11:175-184.

Thorpe, JE. 1989. Developmental variation within salmon populations. Journal of Fish Biology 35(Supplement A):295-303.

Thorpe, JE. 1993. Impacts of fishing on the genetic structure of salmonid populations. In: Cloud, JG, Thorgaard, GH, editors. Genetic conservation of salmonid fishes; New York: Plenum Press.

Thorpe, JE. 2004. Life history responses of fishes to culture. Journal of Fish Biology 65 (Supplement A):263-285.

Thorpe, JE. 1994. Performance thresholds and life-history flexibility in salmonids. Conservation Biology 8:877-879.

Thorpe, JE. 1994. Salmonid fishes and the estuarine environment. Estuaries 17:76-93.

Thorpe, JE. 1998. Salmonid life-history evolution as a constraint on marine stock enhancement. Bulletin of Marine Science 62:465-475.

Thorpe, JE. 1987. Smolting versus residency: developmental conflicts in salmonids. In: Dadswell, MJ, Klauda, RJ, Moffitt, CM, Saunders, RL, Rulifson, RA, Cooper, JE, editors. Common strategies of anadromous and catadromous fishes, American Fisheries Society Symposium 1. American Fisheries Society Symposium 1. p. 224-252.

Thorpe, JE, Mangel, M, Metcalfe, NB, Huntingford, FA. 1998. Modeling the proximate basis of salmonid life-history variation, with application to Atlantic salmon, Salmo salar L. Evolutionary Ecology 12:581-599.

Tiffan, KF, Garland, RD, Rondorf, DW. 2002. Quantifying flow-dependent changes in subyearling fall Chinook salmon rearing habitat using two-dimensional spatially-explicit modeling. North American Journal of Fisheries Management 22:713-726.

Tiffan, KF, Rondorf, DW, Wagner, PG. 2000. Physiological development and migratory behavior of subyearling fall Chinook salmon in the Columbia River. North American Journal of Fisheries Management 20:28-40.

Titus, RG, Volkoff, MC, Snider, WM. 2004. Use of otolith microstructure to estimate growth rates of juvenile Chinook salmon from a Central Valley, California stock. In: Feyrer, FL, Brown, RL, Orsi, JJ, editors . Early life history of fishes in the San Francisco Estuary and watershed. American Fisheries Society Symposium 39. Bethesda, Maryland : American Fisheries Society. p. 181-202.

Tobin, JHI. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. Kenai, Alaska: United States Fish and Wildlife Service, Region 7.

Travis, J, Cokeman, FC, Grimes, CB, Conover, D, Bert, TM, Tringali, M. 1998. Critically assessing stock enhancement: an introduction to the Mote Symposium. Bulletin of Marine Science 62:305-311.

Tri-Dam Project. 2001. Three year evaluation of predation in the Stanislaus River. https://ecosystem.calfed.ca.gov/WRRC/CalFed/people/spcramer/proposal/99982173764/compilation-b

Trudel, M, Geist, DR, Welch, DW. 2004. Modeling the oxygen consumption rates in Pacific salmon and steelhead: as assessment of current models and practices. Transactions of the American Fisheries Society 133:326-348.

Tucker, ME, Martin, CD, Gaines, PD. 2003. Spatial and temporal distribution of Sacramento pikeminnow and striped bass at the Red Bluff Diversion Complex, including the Research Pumping Plant, Sacramento River, California: January, 1997 to August, 1998. Red Bluff, California: U. S. Fish and Wildlife Service. Red Bluff Research Pumping Plant Report Series.

Tucker, ME, Williams, CM, Johnson, RR. 1998. Abundance, food habits and life history aspects of Sacramento squawfish and striped bass at the Red Bluff Diversion Complex, including the Research Pumping Plant, Sacramento, California, 1994-1996. Red Bluff, California: U. S. Fish and Wildlife Service.

Turner, JL. 1966. Introduction to fisheries studies in the Sacramento-San Joaquin Delta. In: Turner, JL, Kelley, DW, Editors. Ecological studies of the Sacramento-San Joaquin Delta, Part II. Fish Bulletin 136.

United States Bureau of Reclamation (USBR). 2000. Draft environmental assessment/initial study for Mill Creek anadromous fish adaptive management enhancement plan. Shasta Lake, California: USBR, Northern California Area Office.

United States Bureau of Reclamation (USBR). 2004. Long-term Central Valley Project operations criteria and plan, CVP-OCAP. Sacramento, California: Bureau of Reclamation.

United States Fish and Wildlife Service (USFWS). 2001. Biological assessment of artificial propagation at Coleman National Fish Hatchery and Livingston Stone National Fish Hatchery: program description and incidental take of chinook salmon and steelhead trout. Red Bluff, California:

United States Fish and Wildlife Service (USFWS). 1998. Central Valley Project Improvement Act tributary production enhancement report. Sacramento, CA:

United States Fish and Wildlife Service (USFWS). 1999. Effects of temperature on early-life survival of Sacramento River fall- and winter-run chinook salmon. Red Bluff, California: USFWS.

United States Fish and Wildlife Service (USFWS). 1988. Fish passage action program for the Red Bluff Diversion Dam. Final report on fishery investigations.

United States Fish and Wildlife Service (USFWS). 2000. Impacts of riprapping to ecosystem functioning, lower Sacramento River, California. Sacramento, California: USFWS.

United States Fish and Wildlife Service (USFWS). 1984. Results of the food habitats study on juvenile Chinook salmon in the lower American River - March to June 1983. Sacramento, California:

United States Fish and Wildlife Service (USFWS). 1995. Working paper on restoration needs: habitat actions to double natural production of anadromous fish in the Central Valley of California. Stockton, CA:

Unwin. M. J. 1986. Stream residence time, size characteristics, and migration patterns of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) from a tributary of the Rakaia River, New Zealand. New Zealand Journal of Marine and Freshwater Research 20:231-252.

Unwin, MJ. 1997. Fry-to-adult survival of natural and hatchery-reared chinook salmon (*Oncorhynchus tshawytscha*) from a common origin. Canadian Journal of Fisheries and Aquatic Sciences 54:1246-1254.

Unwin, MJ, Glova, GJ. 1997. Changes in life history parameters in a naturally spawning population of chinook salmon (*Oncorhynchus tshawytscha*) associated with releases of hatchery-reared fish. Canadian Journal of Fisheries and Aquatic Sciences 54:1235-1245.

Unwin, MJ, Kinnison, MT, Boustead, NC, Quinn, TP. 2003. Genetic control over survival in Pacific salmon (*Oncorhynchus* spp.): experimental evidence between and within populations of New Zealand chinook salmon (*O. tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 60:1-11.

Unwin, MJ, Quinn, TP, Kinnison, MT, Boustead, NC. 2000. Divergence in juvenile growth and life history in two recently colonized and partially isolated chinook salmon populations. Journal of Fish Biology 57:943-960.

Utter, F, Milner, G, Stahl, G, Teel, D. 1989. Genetic population structure of chinook salmon, *Oncorhynchus tshawystcha*, in the Pacific Northwest. Fishery Bulletin 87:239-264.

Utter, FMWRS, Teel, DJ. 1992. Genetic isolation of previously indistinguishable chinook populations from the Snake and Klamath Rivers: limitations of negative data . Fishery Bulletin 90:770-777.

Utter, F. 1998. Genetic problems of hatchery-reared progeny released into the wild, and how to deal with them. Bulletin of Marine Science 62:623-640.

Utter, F. 2001. Patterns of subspecific anthropogenic introgression in two salmonid genera. Reviews in Fish Biology and Fisheries 10:265-279.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893:901.

Van Hyning, JM. 1957. Stock-recruitment relationships for Columbia River chinook salmon. Conseil International pour l'Exploration de la Mer 164:89-97.

Van Winkle, W, Jager, HI, Holcomb, BD. 1996. An individual-based instream flow model for coexisting populations of brown and rainbow trout. Palo Alto, CA: EPRI.

Van Woert, W. 1964. Mill Creek Counting Station. Memorandum to Elden Hughes. California Dept. of Fish and Game.

Vander Haegen, GE, Ashbrook, CE, Yi, KW, Dixon, JF. 2004. Survival of spring Chinook salmon captured and released in a selective commercial fishery using gill nets and tangle nets. Fisheries Research 68:123-133.

Vander Hagen, GE, Tipping, JM, Hammer, SA. 1998. Consumption of juvenile salmonids by adult steelhead in the Cowlitz River, Washington. California Fish and Game 84:48-50.

Vaux, WG. 1968. Intergravel flow and interchange of water in a streambed. United States Fish and Wildlife Service Fishery Bulletin 66:479-489.

Vaux, WG. 1962. Interchange of stream and intragravel water in a salmon spawning riffle. United States Fish and Wildlife Service Special Report - Fisheries.

Velsen, FPJ. 1987. Temperature and incubation in Pacific salmon and rainbow trout: compilation of data on median hatching time, mortality, and embryonic staging. Canadian Data Report in Fisheries and Aquatic Sciences.

Venditti, DA, Garland, RD. 1994. Nearshore movement and feeding behavior of juvenile fall Chinook salmon in the Columbia River. In: Rondorf, DW, Tiffan, KF, editors. Identification of the spawning, rearing and migratory requirements of fall Chinook salmon in the Columbia River. 1994 Annual Report to Bonneville Power Administration. Portland, Oregon: p. 80-98.

Viant, MR, Werner, I, Rosenblum, ES, Gantner, AS, Tjeerdema, RS, Johnson, ML. 2003. Correlation between heat-shock protein induction and reduced metabolic condition in juvenile steelhead trout (*Oncorhynchus mykiss*) chronically exposed to elevated temperature. Fisheries Board of Scotland, Annual Report 22 (Part 3) 29:159-171.

Vick, J, McBain and Trush. 2004. Tuolumne River floodway restoration, project design approach and rationale. Arcata, California: McBain and Trush.

Vogel, DA. 1982. Preferred Spawning Velocities, Depths, and Substrates for Fall Chinook Salmon in Battle Creek, California. Red Bluff, California: U.S. Fish and Wildlife Service.

Vogel, DA. 1989. Tehama-Colusa Canal Diversion and Fishery Problems Study . Red Bluff, California: U.S. Fish and Wildlife Service. Final Report. USFWS Report No. AFF1/FAO-89-06.

Vogel, DA, Marine, KR, Smith, JG. 1988. Fish passage action program for Red Bluff Diversion Dam - final report on fishery investigations. Red Bluff, California: U. S. Fish and Wildlife Service, Northern Central Valley Fishery Resource Office.

Vogel, DA, Smith, JG, Marine, KR. 1988. Fish passage action program for Red Bluff Diversion Dam: Final report on fishery investigation, including executive summary. Report No. FR1/FAO-88-19. U.S. Fish and Wildlife Service.

Vogel, DA, Marine, KR. 1991. Guide to upper Sacramento River chinook salmon life history. Redding, California: CH2M Hill.

Vogel, S. 1994. Life in moving fluids. Princeton, New Jersey: Princeton University Press.

Volk, EC, Schroder, SL, Grimm, JJ. 1994. Use of a bar code symbology to produce multiple thermally induced otolith marks. Transactions of the American Fisheries Society 123:811-816.

Volkman, JM, McConnaha, WE. 1993. Through a glass darkly: Columbia River salmon, the Endangered Species Act, and adaptive management. Environmental Law 23:1249-1272.

Vøllestad Asbjørn, L, Peterson, J, Quinn, TP. 2004. Effects of freshwater and marine growth rates on early maturity in male coho and Chinook salmon. Transactions of the American Fisheries Society 133:495-503.

von Schalburg, KR, Rise, ML, Brown, GD, Davidson, WS, Koop, BF. 2005. A comprehensive survey of the genes involved in maturation and development of the rainbow trout ovary. Biology of Reproduction 72:687-699.

Vronskiy, BB. 1972. Reproductive biology of the Kamchatka River Chinook salmon (*Oncorhynchus tshawytscha* (Walbaum)). Journal of Ichthyology 12:259-273.

Vyverberg, K, Snider, B, Titus, RG. 1997. Lower American River chinook salmon spawning habitat evaluation. California Department of Fish and Game, Environmental Services Division.

Wagner, T, Congleton, JL. 2004. Blood chemistry correlates of nutritional condition, tissue damage, and stress in migrating juvenile chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 61:1066-1074.

Wales, JH, Coots, M. 1954. Efficiency of chinook salmon spawning in Fall Creek, California. Transactions of the American Fisheries Society 84:137-149.

Walters, CJ, Collie, JS. 1988. Is research on environmental factors useful to fisheries management? Canadian Journal of Fisheries and Aquatic Sciences 45:2848-2854.

Walters, CJ, Juanes, F. 1993. Recruitment limitation as a consequence of natural selection for use of restricted feeding habitats and predation risk taking by juvenile fishes. Canadian Journal of Fisheries and Aquatic Sciences 50:2058-2070.

Walters, CJ. 1986. Adaptive management of renewable resources. New York: Macmillian.

Walters, CJ, Hilborn, R. 1976. Adaptive control of fishing systems. Journal of the Fisheries Research Board of Canada 33:145-159.

Wang, S, Hard, JJ, Utter, F. 2002. Salmonid inbreeding: a review. Reviews in Fish Biology and Fisheries 11:301-319.

Waples, RS. 1999. Dispelling some myths about hatcheries. Fisheries 24:12-21.

Waples, RS. 1995. Evolutionarily significant units and the conservation of biological diversity under the Endangered Species Act. In: Nielsen, JL, Editor. Evolution and the aquatic ecosystem: defining unique units in population conservation; Bethesda, Maryland: p. 8-27. American Fisheries Society Symposium 17.

Waples, RS. 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Sciences 48 (Supplement 1):124-133.

Waples, RS. 1991. Pacific salmon, *Oncorhynchus* spp., and the definition of "species" under the Endangered Species Act. U.S. National Marine Fisheries Service Marine Fisheries Review 53:11-22.

Waples, RS, Teel, DJ, Myers, JM, Marshall, AR. 2004. Life history divergence in Chinook salmon: historic contingency and parallel evolution. Evolution 58:386-403.

Ward, BR. 1996. Population dynamics of steelhead trout in a coastal stream, the Keogh River, British Columbia. In: Cox, IG, editor. Stock assessment in inland fisheries. Blackwell Publishing. p. 308-323.

Ward, PD, McReynolds, TR. 2001. Butte and Big Chico creeks spring-run Chinook salmon, *Oncorhynchus tshawytscha* , life history investigations 1998-2000. Inland Fisheries Administrative Report 2001-2. California Department of Fish and Game.

Ward, PD, McReynolds, TR, Garman, CE. 2004b. Butte and Big Chico creeks spring-run Chinook salmon, Oncorhynchus tshawytscha, life history investigation, 2001-2002. Chico, California: California Department of Fish and Game. Inland Fisheries Administrative Report No. 2004-4.

Ward, PD, McReynolds, TR, Garman, CE. 2004a. Butte and Big Chico creeks spring-run Chinook salmon, Oncorhynchus tshawytscha, life history investigation, 2000-2001. Chico, California: California Department of Fish and Game. Inland Fisheries Administrative Report No. 2004-3.

Ward, PD, McReynolds, TR, Garman, CE. 2003. Butte Creek spring-run Chinook salmon, Oncorhynchus tshawytscha pre-spawn mortality evaluation, 2003. Chico, California: California Department of Fish and Game. Inland Fisheries Administrative Report No. 2004-5.

Waring, CP, Moore, AP. 1997. Sublethal effects of a carbamate pesticide on pheronomal mediated endocrine function in mature male Atlantic salmon (*Salmo salar*). Fish Physiology and Biochemistry 17:203-211.

Warner, G. 1991. Remember the San Joaquin. In: Lufkin, A, editor. California's salmon and steelhead. Berkeley:

University of California Press. p. 61-72.

Warner, GH, Fry, DHJr, Culver, AN. 1961. History of yearling king salmon marked and released at Nimbus Hatchery. California Fish and Game 47:343-355.

Warren, WG, Dempson, JB. 1995. Does temporal stratification improve the accuracy of mark-recapture estimates of smolt production? A case study based on the Conne River, Newfoundland. North American Journal of Fisheries Management 15:126-136.

Weatherley, AH, Gill, HS. 1995. Growth. In: Groot, C, Margolis, L, Clarke, WCC, editors. Physiological ecology of Pacific salmon. Vancouver, British Columbia: University of British Columbia Press.

Weber, ED, Fausch, KD. 2004. Abundance and size distribution of ocean-type juvenile Chinook salmon in the upper Sacramento River margin before and after hatchery release. North American Journal of Fisheries Management 24:1447-1455.

Weber, ED, Fausch, KD. 2003a. Competition between hatchery-reared and naturally spawned juvenile chinook salmon in the Sacramento River, California. Fort Collins: Colorado State University, Department of Fishery and Wildlife Biology.

Weber, ED, Fausch, KD. 2005. Competition between hatchery-reared and wild juvenile Chinook salmon in enclosures in the Sacramento River, California. Transactions of the American Fisheries Society 134:44-58.

Weber, ED, Fausch, KD. 2003b. Interactions between hatchery and wild salmonids in streams: differences in biology and evidence for competition. Canadian Journal of Fisheries and Aquatic Sciences 60:1018-1036.

Weber, LP, Higgins, PS, Carlson, RI, Janz, DM. 2003. Development and validation of methods for measuring multiple biochemical indices of condition in juvenile fishes. Journal of Fish Biology 63:637-658.

Weber, PK, Hutcheon, ID, McKeegan, KD, Ingram, BL. 2002. Otolith sulfur isotope method to reconstruct Chinook salmon (*Oncorhynchus tshawytscha*) life history. Canadian Journal of Fisheries and Aquatic Sciences 59:587-591.

Wege, GJ, Anderson, RO. 1978. Relative weight ($R_w$): a new index of condition for largemouth bass. In: Novinger, GD, Dillard, JG, editors. New approaches to the management of impoundments. Special Publication 5 . Bethesda, Maryland: American Fisheries Society, North Central Division. p. 79-91.

Weissmar, RC, Simenstad, CA. 1998. Variability of estuarine and riverine ecosystem productivity for supporting Pacific salmon . In: McMurray, GR, Bailey, RJ, editors. Change in Pacific Northwest Coastal Ecosystems. MOAA Decision Analysis Series. Silver Springs, Maryland: NOAA Costal Ocean Program. p. 253-301 .

Welch, DW, Ishida, Y, Nagasawa, K. 1998. Thermal limits and ocean migrations of sockeye salmon (*Oncorhynchus nerka*): long-term consequences of global warming. Canadian Journal of Fisheries and Aquatic Sciences 55:937-948.

Welch, DW, Ward, BR, Smith, BD, Everson, JP. 2000. Temporal and spatial responses of British Columbia steelhead (*Oncorhynchus mykiss*) populations to ocean climate shifts. Fisheries Oceanography 9:17-32.

Wells, BK, Rieman, BE, Clayton, JL, Horan, DL, Jones, CM. 2003. Relationships between water, otolith, and scale chemistries of west slope cutthroat trout from the Coeur d'Alene River, Idaho: the potential application of hard-part chemistry to describe movements in freshwater. Transactions of the American Fisheries Society 132:409-424.

Wells, BK, Grimes, CB, Field, JC, Reiss, CS. 2006. Co variation between the average lengths of mature coho (*Oncorhynchus kisutch*) and Chinook salmon (*O. tshawytscha*) and the ocean environment. Fisheries Oceanography 15:67-79.

Wells, RA, W. J. McNeil. 1970. Effect of quality of the spawning bed on the growth and development of pink salmon embryos and alevins, Special Scientific Report-fisheries 616. U.S. Fish and Wildlife Service.

Welsh, SA, Perry, SA. 1998. Influence of spatial scale on estimates of substrate use by benthic darters. North American Journal of Fisheries Management 18:954-959.

Werner, I, Smith, TB, Feliciano, J, Johnson, ML. 2005. Heat shock proteins in juvenile steelhead reflect thermal conditions in the Navarro River Watershed, California. Transactions of the American Fisheries Society 134:399-410.

Wertheimer, AC, Smoker, WW, Joyce, TL, Heard, WR. 2001. Comment: a review of the hatchery programs for pink salmon in Prince William Sound and Kodiak Island, Alaska. Transactions of the American Fisheries Society 130:712-720.

White, J, Kjelson, M, Brandes, PL, McLain, JS, Greene, SOB, Sitts, R. 2001. The use of the Environmental Water Account for the protection of anadromous salmonids in the Sacramento-San Joaquin Delta in 2000-2001. Sacramento, California: CALFED Bay-Delta Program.

Wickett, WP. 1954. The oxygen supply to salmon eggs in spawning beds. Journal of the Fisheries Research Board of Canada 11:933-953.

Wickwire, RH, Stevens, DE. 1971. Migration and distribution of young king salmon, *Oncorhynchus tshawytscha*, in the Sacramento River near Collinsville, Anadromous Fisheries Branch, Administrative Report 71-4. California Department of Fish and Game.

Wiener, JG, Gilmour, CC, Krabbenhoft, DP. 2003. Mercury strategy for the Bay-Delta ecosystem: a unifying framework for science, adaptive management, and ecological restoration. University of Wisconsin-La Crosse.

Wilcock, PR, Barta, AF, Shea, CC, Kondolf, GM, Matthews, WVG, Pitlick, J. 1996. Observations of flow and sediment entrainment on a large gravel-bed river. Water Resources Research 32:2897-2909.

Wilkerson, FP, Dugdale, RC, Marchi, A, Collins, CA. 2002. Hydrography, nutrients and chlorophyll during El Niño and Laña 1997-99 in the Gulf of the Farallones, California. Progress in Oceanography 54:293-310.

Willamette/Lower Columbia Technical Recovery Team (W/LCTRT). 2003. Interim report on viability criteria for Willamette and Lower Columbia Basin Pacific salmonids. Seattle, Washington: NOAA Fisheries, National Marine Fisheries Service, Northwest Fisheries Science Center.

Williams, JG. 2001a. Chinook salmon in the lower American River, California's largest urban stream. In: Brown, RL, editor. Contributions to the biology of Central Valley salmonids, Fish Bulletin No. 179. 2. p. 1-38.

Williams, JG. 1996. Lost in space: minimum confidence intervals for idealized PHABSIM studies. Transactions of the American Fisheries Society 125:458-465.

Williams, JG. 1995. Report of the Special Master, Environmental Defense Fund et al. v. East Bay Municipal Utility District, Alameda County (California) Superior Court Action No. 425955.

Williams, JG. 1999. Stock dynamics and adaptive management of habitat: an evaluation based on simulations. North American Journal of Fisheries Management 19:329-341.

Williams, JG. 2001b. Testing models used for instream flow assessment. Fisheries 26:19-20.

Williams, JG, Kondolf, GM. 1999. Rehabilitation concepts for Clear Creek, Shasta County, California. Berkeley, California: G. M. Kondolf.

Williams, JG, Kondolf, GM, Ginney, E. 2002. Geomorphic assessment of Butte Creek, Butte County, California. Report to the USFWS, Stockton, CA. http://www.delta.dfg.ca.gov/afro/ws_docs.asp?code=BUTTC

Williams, JG, Speed, TP, Forrest, WF. 1999. Comment: transferability of habitat suitability criteria. Transactions of the American Fisheries Society 19:623-625.

Williamson, KS, May, B. 2003. Homogenization of fall-run chinook salmon gene pools in the Central Valley of California, USA. Completion Report for CALFED Grant #97-C09. University of California Davis.

Williamson, KS, May, B. 2005. Homogenization of fall-run Chinook salmon gene pools in the Central Valley of California, USA. North American Journal of Fisheries Management 25:993-1009.

Williamson, KS, May. Bernie. 2005. Inheritance studies implicate a genetic mechanism for apparent sex reversal in Chinook salmon. Transactions of the American Fisheries Society 134:1253-1264.

Williamson, SC, Bartholow, JM, Stalnaker, CB. 1993. Conceptual model for quantifying pre-smolt production from flow-dependent physical habitat and water temperature. Regulated Rivers: Research and Management 8:15-28.

Wilson, MF. 1997. Variation in salmonid life histories: patterns and perspectives. Portland, Oregon: USDA, Forests Service, Pacific Northwest Research Station. Research Paper.

Wilson, MF, Gende, SM, Mars ton, BH. 1998. Fishes and the forest: expanding perspectives on fish-wildlife interactions. Bioscience 48:455-462.

Winans, GA, Viele, D, Grover, A, Plamer-Zwahlen, M, Teel, D, Van Doornik, D. 2001. An update of genetic stock identification of chinook salmon in the Pacific Northwest: test fisheries in California. Reviews in Fisheries Science 9:213-237.

Wipfli, MS, Hudson, JP, Caouette, JP. 1998. Influence of salmon carcasses on stream productivity: response of biofilm and benthic macroinvertebrates in southeastern Alaska, U.S.A. Canadian Journal of Fisheries and

Aquatic Sciences 55:1503-1511.

Wipfli, MS, Hudson, JP, Caquetter, JP, Chaloner, DT. 2003. Marine subsidies in freshwater ecosystems: salmon carcasses increase the growth rates of stream-resident salmonids. Transactions of the American Fisheries Society 132:371-381.

Wipfli, MS, Hudson, JP, Chaloner, DT, Caoutte, JP. 1999. Influence of salmon spawner densities on stream productivity in Southeast Alaska. Canadian Journal of Fisheries and Aquatic Sciences 56:1600-1611.

Wiplfi, MS, Hudson, JP, Caquette, JP. 2004. Restoring productivity of salmon-based food webs: contrasting effects of salmon carcass and salmon carcass analog additions on stream-resident salmonids. Transactions of the American Fisheries Society 133:1440-1454.

Withler, FC. 1982. Transplanting Pacific salmon. Canadian Technical Report of Fisheries and Aquatic Sciences 1079.

Withler, IL. 1966. Variability in life history characteristics of steelhead trout (Salmo gairdneri) along the Pacific Coast of North America. Journal of the Fisheries Research Board of Canada 23:365-393.

Wixom, LH, Pisciotto, J, Lake, C. 1995. Final performance report - Sacramento river system sport fish catch inventory. Sacramento, California: California Department of Fish and Game, Inland Fisheries Division.

Woods, PF. Nolan, KM, Kelsey, HM, Marron, DC. 1995. Geomorphic processes and aquatic habitat in Redwood Creek Basin, Northwestern California. U. S. Geological Survey Professional Paper 1454-T.

Wootton, JT, Parker, MS, Power, ME. 1996. Effects of disturbance on river food webs. Science 273:1558-1561.

Workman, ML. 99. An assessment of the downstream migration of juvenile Chinook salmon (*Oncorhynchus tshawytscha*) in the lower Mokelumne River [ms thesis]. California State University, Sacramento.

Workman, ML. 2002. Downstream migration monitoring at Woodbridge Dam on the Lower Mokelumne River, California, December 2000 through July 2001. Lodi, California: East Bay Municipal Utility District.

Worman, A, Packman, AI, Johansson, H, Jonsson, K. 2002. Effect of flow-induced exchange in hyporheic zones on longitudinal transport of solutes in streams and rivers. Water Resources Research 38:2-1 - 2-15.

Wright, S. 1932. The roles of mutation, inbreeding, crossbreeding and selection in evolution. Proceedings of the 6th International Congress on Genetics; p. 356-366.

Wright, S. 1988. Surfaces of selective value revisited. American Naturalist 131:115-123.

Wu, FC. 2000. Modeling Embryo Survival Affected by Sediment Deposition Into Salmonid Spawning Gravels: Application to Flushing Flow Prescriptions. ISI:000087226800020

Wurster, CM, Patterson, WP, Stewart, DJ, Bowlby, JN, Stewart, TJ. 2005. Thermal histories, stress, and metabolic rates of Chinook salmon (*Oncorhynchus tshawytscha*) in Lake Ontario: evidence from intra-otolith stable isotope analyses. Canadian Journal of Fisheries and Aquatic Sciences 62:700-713.

Yoshiyama, RM. 1999. A history of salmon and people in the Central Valley region of California. Reviews in Fisheries Science 7:197-239.

Yoshiyama, RM, Fisher, FW. 2001. Long time past: Baird Station and the McCloud Wintu. Fisheries 26(1):6-22.

Yoshiyama, RM, Gerstang, ER, Fisher, FW, Moyle, PB. 2000. Chinook salmon in the California central valley: an assessment. Fisheries 25(2):6-20.

Yoshiyama, R. 1999. A history of salmon and people in the Central Valley region of California. Reviews in Fisheries Science 7:197-239.

Yoshiyama, RM, Gerstung. Eric R., Fisher, FW, Moyle, PB. 2000. Chinook salmon in the Central Valley of California: an assessment. Fisheries 25:6-20.

Yoshiyama, RM, Gerstung, ER, Fisher, FW, Moyle, PB. 2001. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. In: Brown, RL, editor. Fish Bulletin 179: Contributions to the biology of Central Valley salmonids. 1. Sacramento: p. 71-176.

Yoshiyama, RM, Gerstung, ER, Fisher, FW, Moyle, PB. 1996. Historical and present distributions of Chinook salmon in the Central Valley drainage of California. In: Sierra Nevada Ecosystem Project, Status of the Sierra Nevada, Volume III. Final Report. p. 309-362.

Young, KA. 1999. Managing the decline of Pacific salmon: metapopulation theory and artificial recolonization as ecological mitigation. Canadian Journal of Fisheries and Aquatic Sciences 56:1700-1706.

Young, KA. 2004. Toward evolutionary management. In: Hendry, AP, Stearns, SC, editors. Evolution

illuminated: salmon and their relatives . Oxford University Press. p. 358-376.

Young, MK, Hubert, WA, Wesche, TA. 1990. Comment: fines in redds of large salmonids. Transactions of the American Fisheries Society 119:156-162.

Zabel, RW. 2002. Using "travel time" data to characterize the behavior of migrating animals. The American Naturalist 159:372-387.

Zabel, RW, Williams, JG. 2002. Selective mortality in chinook salmon: what is the role of human disturbance? Ecological Applications 12:173-183.

Zaugg, WS. 1981. Relationships between smolt indices and migration in controlled and natural environments. In: Brannon, EL, Salo, EO, editors. Salmon and trout migratory behavior symposium; Seattle: University of Washington Press. p. 173-183.

Zaugg, WS, Wagner, HH. 1973. Gill ATPase activity related to parr-smolt transformation in steelhead trout *Salmo gairdneri*: influence of photoperiod and temperature. Comparative Biochemistry and Physiology 45:955-965.

Zhang, Z, Beamish, RJ, Riddell, BE. 1995. Differences in otolith microstructure between hatchery-reared and wild Chinook salmon (*Oncorhynchus tshawytscha*). Canadian Journal of Fisheries and Aquatic Sciences 52:344-352.

Zimmerman, CE. 2003. Migration of precocious male hatchery Chinook salmon in the Umatilla River, Oregon. North American Journal of Fisheries Management 23:1006-1014.

Zimmerman, CE, Reeves, GH. 2002. Identification of steelhead and resident rainbow trout progeny in the Deschutes River, Oregon, revealed with otolith microchemistry.

Zimmerman, CE, Reeves, GH. 2000. Population structure of sympatric anadromous and nonanadromous Oncorhynchus mykiss: evidence from spawning surveys and otolith microchemistry. Canadian Journal of Fisheries and Aquatic Sciences 57:2152-2162.

# Attachment 21

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# ENERGY DOWN THE DRAIN

## *The Hidden Costs of California's Water Supply*


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NATURAL RESOURCES DEFENSE COUNCIL
PACIFIC INSTITUTE, OAKLAND, CALIFORNIA
August 2004

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The Natural Resources Defense Council is a national nonprofit environmental organization with more than 1 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, and San Francisco. Visit us at www.nrdc.org.

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The Pacific Institute is dedicated to protecting our natural world, encouraging sustainable development and improving global security. Founded in 1987 and based in Oakland, California, we provide independent research and policy analysis on issues at the intersection of development, environment, and security. Our aim is to find real-world solutions to problems like water shortages, habitat destruction, global warming, and environmental terrorism.


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# CONTENTS


**Acknowledgments** iv

**Executive Summary** v

**Chapter 1: The High Cost of Energy Use in Western Water Systems** 1

**Chapter 2: The Connections Between Water and Energy** 7

**Chapter 3: San Diego County—Energy and Urban Water** 28

**Chapter 4: Westlands Water District—Energy and Agricultural Water** 37

**Chapter 5: The Columbia River Basin—Energy and Hydropower** 46

**Chapter 6: Recommendations for Water Policy** 55

**Appendices** 63

Appendix A: Urban Model Description 63

Appendix B: San Diego Case Study Data Sources and Assumptions 70

Appendix C: Agricultural Model Description 73

**Endnotes** 75




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THE EARTH'S BEST DEFENSE

# ENERGY DOWN THE DRAIN

*The Hidden Costs of California's Water Supply*

August 2004

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THE EARTH'S BEST DEFENSE

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August 2004

## ACKNOWLEDGMENTS

NRDC would like to thank The William and Flora Hewlett Foundation and the Compton Foundation, Inc. for funding this report. We thank Ruth and Ben Hammett, the David L. Klein, Jr. Foundation, George A. Miller, Faye and Sandor Straus, and two anonymous donors for their ongoing support of NRDC's Western Water Project, which laid the foundation for this report. We also thank our members, without whom none of our work would be possible. Pacific Institute would like to thank the New Land Foundation.

This report reflects the contributions of many individuals. The authors would first and foremost like to thank Professor Robert Wilkinson of the University of California, Santa Barbara, School of Environmental Science and Management, on whose excellent earlier work this report is based. Peter Gleick, president of the Pacific Institute for Studies in Development Environment and Security, provided helpful guidance and insight. Michael Matz conducted excellent preliminary research and interviews. Jeannine Larabee helped develop the spreadsheet model used in the case studies. The staffs of the San Diego County Water Authority and the Westlands Water District were tremendously helpful in compiling data needed for our case studies, and they provided useful comments on early drafts. We would also like to thank the following individuals, who graciously gave their time to be interviewed in the course of our research: Dave Christy, Western Area Power Administration, Public Affairs Office; Mary Ann Dickinson, executive director, California Urban Water Conservation Council; Lisa Maddaus, technical adviser, California Urban Water Conservation Council; Kamyar Guivetchi, manager, Statewide Water Planning, Department of Water Resources; Barry Mortimeyer, chief, Central Valley Operations Division, United States Bureau of Reclamation; Steve Macaulay, executive director, California Urban Water Agencies; and Stephen Kashiwada, chief, Division of Operations and Maintenance, Department of Water Resources. For their assistance regarding Columbia River issues, we thank Dale Hellewell, Grant County Public Utility District (Washington); Bill Griffin, Pacificorp; Dick Watson, Northwest Power and Conservation Council; Charles Plummer, United States Department of Agriculture; Karen Russell, Water Watch (Oregon); John Taves, Bonneville Power Administration; Bert Bowler, Idaho Rivers United; Steve Weiss, Northwest Energy Coalition; Mike Beus, Bureau of Reclamation (Pacific Northwest); Ron Carlson; Rick Wells; Ron Rodewald, Bonneville Power Administration; Jim Blanchard, Bureau of Reclamation; and Ric Gale, Idaho Power. We are also grateful for the insightful comments on earlier drafts provided by Dr. Jay Lund, Karen Garrison, Andrew Englander, Laura Bodie, John Fazio, Ken Weinberg, Jeff Stephenson, Russ Freeman, Steve Malloch, Sheryl Carter, and several anonymous reviewers.

# EXECUTIVE SUMMARY

California has been through its share of scorching droughts and energy shortages, but many residents of the western United States may not realize the close connections between water and power resources. Water utilities use large amounts of energy to treat and deliver water. Even after utilities deliver water, consumers burn more energy to heat, cool, and use the water.

▶ The California State Water Project is the largest single user of energy in California. In the process of delivering water from the San Francisco Bay-Delta to Southern California, the project uses 2 to 3 percent of all electricity consumed in the state.

▶ The State Water Project burns energy pumping water 2,000 feet over the Tehachapi Mountains—the highest lift of any water system in the world. The amount of energy used to deliver that water to residential customers in Southern California is equivalent to approximately one-third of the total average household electric use in the region.

▶ Ninety percent of all electricity used on farms is devoted to pumping groundwater for irrigation.

Despite these connections, water planners at the federal, state, and local levels have largely failed to consider the energy implications of their decisions. Water agencies select water sources without assessing the energy costs of transporting the water over great distances to its users. Likewise, they fail to consider the energy savings of using less water. This kind of disregard for the energy implications of water leads to high costs for consumers and wasteful water-supply decisions.

A proper understanding of water and energy, however, can save both money and resources. Our report presents a model for how policymakers can calculate the amount of energy consumed in water use. We applied this model to three case studies in the western United States, and our analysis shows that integrating energy use into water planning can save money, reduce waste, protect our environment, and strengthen our economy. Water planners can use this model in their own regions to find similar solutions that will benefit consumers and the environment alike.

## KEY FINDINGS

We quantitatively evaluated the connections between energy and water in three case studies. We used San Diego County's search for future water supply options to highlight energy use in urban water systems. Our examinations of the Westlands Water District and the Columbia River Basin illustrate energy use in agricultural settings. Our research found the following.

**Water conservation lowers energy use and energy bills.** The San Diego case study revealed that end use of water—especially energy intensive uses like washing clothes and taking showers—consumes more energy that any other part of the urban water conveyance and treatment cycle. This is a rather striking finding since conveyance is a much more obvious energy consumer, particularly in Southern California. Therefore, reducing water use can save significant amounts of energy. For instance, if



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*The Hidden Costs of California's Water Supply*

August 2004

San Diego relied on conservation instead of additional water from Northern California to provide the next 100,000 acre-feet of water, it would save enough energy to provide electricity for 25 percent of all of the households in San Diego.

**Water recycling is a highly energy efficient water source.** In both urban and agricultural settings, reusing water is far less energy intensive than any physical source of water other than local surface water. For example, Orange County is constructing a water recycling system that will use only half the amount of energy required to import the same amount of water from Northern California. Even groundwater pumping is more energy intensive in San Diego and the Westlands Water District than water recycling from urban wastewater; and the depth to groundwater in these locations is not atypical for western settings.

*Orange County is constructing a water recycling system that will use only half the amount of energy required to import the same amount of water from Northern California.*

**Retiring agricultural land may increase energy use if the water is transferred to other agricultural or urban uses.** Transferring water from retired, drainage-impaired Westlands land to urban settings would dramatically increase energy use because urban water use is typically more energy intensive. For example, we estimate that transferring the conserved water to San Diego would require an additional 1.3 billion kWh/yr compared to leaving that water in the delta. Allowing water to remain in Westlands would likely result in an increase in permanent crops and a significant increase in embedded energy ranging from 16 percent to 48 percent depending on assumptions.

**Retiring agricultural land can save energy if the water is dedicated to the environment.** Using data from the Westlands Water District—one of the largest agricultural users of water in the West—we concluded that ending irrigation to retired farmlands could generate large energy savings if the water remains instream. Retiring 100,000 acres of drainage-impaired farmland in Westlands, with corresponding reductions in Central Valley Project deliveries, could save at least 71 million kWh from reduced Central Valley Project pumping. This is enough to meet the residential energy needs for the city of Modesto for two months. Retiring this land could also save an additional 50 million equivalent kilowatt-hours used for cultivation and harvest.

**Diverting water above dams costs power and money.** Our Columbia case study demonstrates that when water is diverted for irrigation before it reaches a dam, an enormous amount of energy—the foregone energy production—is lost. For example, the foregone energy production in the Columbia Basin Project is the equivalent of 30 percent of the total energy use for the city of Seattle. This loss may be large enough, in dry years, to make it possible to pay farmers more than they could earn growing low-value crops and still have enough money to purchase environmental flows when they are most valuable.

## RECOMMENDATIONS

All three of our case studies demonstrate that including energy considerations in water management decisions can lead to significant energy—and money—savings.

The case study analysis supports two primary recommendations for how policy makers can begin to achieve these savings.

**Decision makers should better integrate energy issues into water policy decision making.** Looking at energy use and water use simultaneously generates valuable insights that do not arise from separate policy analyses of water and energy issues. We therefore recommend:

- Modifying state planning tools, such as the Urban Water Management Planning Act and Bulletin 160, among others, to require inclusion of energy use and costs;
- Improving coordination among resource management agencies to better identify and address the energy implications of water policy decisions;
- Conducting an energy intensity analysis of the United States Bureau of Reclamation's distribution systems and identifying regions and districts where large amounts of power are required to deliver water;
- Exploring the retirement of drainage-impaired lands in the Central Valley in order to reduce energy use and generate water to help restore the delta;
- Developing partnerships designed to produce energy, economic, and environmental benefits through voluntary water transfers in the Columbia River Basin and elsewhere, with a focus on dry-year transfers where large water diversions reduce downstream flows and hydropower generation.

**Both water and energy policymakers should give water conservation higher priority.** Surprisingly, policy actions that affect end uses of water may have much larger energy implications than policy actions that affect the mix of physical water sources. We conclude that conservation has much greater potential, and stronger energy-related economic and environmental benefits, than has been recognized to date. In addition, the energy benefits of conservation can generate air quality and climate change benefits. Given this strong finding, we recommend:

- Prioritizing conservation funding;
- Enforcing existing conservation requirements;
- Requiring water measurement;
- Promoting conservation through conservation pricing;
- Offering conservation incentives;
- Implementing measures to ensure conservation savings.

CHAPTER 1

# THE HIGH COST OF ENERGY USE IN WESTERN WATER SYSTEMS

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*The Hidden Costs of California's Water Supply*

August 2004

Water use and energy use are closely linked. Providing and using water consume large amounts of energy. Energy production frequently uses or pollutes water.[1] Most electricity production also contributes to global climate change, which is likely to have tremendous impacts on water availability and management. Yet energy and water issues are rarely considered together. This is as true at the policy level as it is at the personal level. Most consumers certainly do not realize that saving water is an excellent way to save energy and, indirectly, to reduce air pollution.

The California Water Code notes that wasting water is an unreasonable use of energy.[2] Yet none of the existing resource planning efforts meaningfully addresses the interplay between the two issues, let alone their relationship with climate change. Even the California Energy Commission (CEC) has noted this failure. A CEC report to the state legislature noted: "The State appears to not be consciously managing its rapidly evolving water and energy policies in a coherent manner."[3] Integration of energy considerations into water policy and planning is long overdue.

This report explores the energy implications of water use and presents a methodology for incorporating energy impacts into water resource decisions. It relies heavily on data and examples from California but includes a case study from the Northwest.

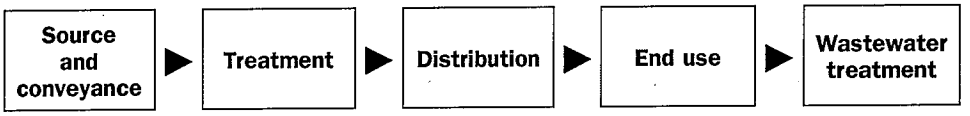
## THE LINKS IN THE WATER-ENERGY CHAIN

The more than 60,000 water systems and 15,000 wastewater systems in the United States are among the country's largest energy consumers, using about 75 billion kWh/yr nationally—3 percent of annual U.S. electricity consumption.[4] This demand is equivalent to the entire residential demand for the state of California and does not even include energy for what is called end use: the energy required to further treat, circulate, heat, or cool water at the consumer level.[5] Even if all of this power came from relatively clean modern natural-gas-fired power plants, producing the energy used

by water systems would release approximately 30 million tons of carbon dioxide—the equivalent of more than 4 million cars.[6]

Many of the peak demands for water and the energy required to treat and transport that water coincide with the peak seasonal energy demands experienced by the electrical utilities, particularly in areas with hot summers like Southern California.[7] Thus, reducing the energy required to move, use, and treat water could help avoid power outages and avoid or delay the need for new power facilities.

This report divides the water supply-use-disposal chain into five stages.[8]




▶ *Source and conveyance:* Significant amounts of energy may be required to create a usable source of water and bring it to where it will be treated or consumed. Most water used in the United States is diverted from surface sources such as rivers and streams or pumped from groundwater aquifers. Smaller amounts of freshwater are produced from salt water, brackish water, or wastewater using desalination or water-recycling technologies. Desalination requires energy to remove salts from water using reverse osmosis or other processes. Water recycling requires energy to remove pollutants from wastewater.

Water is either used near its source or transported for storage and use elsewhere. Conveying water often requires pumping the water over hills and mountains or into storage facilities—a process that can require large amounts of energy. Such systems

**FROM SOURCE TO TAP: THE HIGH ENERGY COST OF MOVING WATER**

Moving large quantities of water over long distances and significant elevations is a highly energy intensive task. For this reason, water systems in the West are particularly energy intensive. According to the Association of California Water Agencies, water agencies account for 7 percent of California's energy consumption and 5 percent of the summer peak demand.

The State Water Project (SWP) is the largest single user of energy in California. It consumes an average of 5 billion kWh/yr, more than 25 percent of the total electricity consumption for the entire state of New Mexico. The California Energy Commission reports that SWP energy use accounts for 2 to 3 percent of all electricity consumed in California.

The SWP consumes so much energy because of where it sends its water. To convey water to Southern California from the Sacramento–San Joaquin Delta, the SWP must pump it 2,000 feet over the Tehachapi Mountains, the highest lift of any water system in the world. Pumping one acre-foot of SWP water to the region requires approximately 3,000 kWh. Southern California's other major source of imported water is also energy intensive: pumping one acre-foot of Colorado River Aqueduct water to Southern California requires about 2,000 kWh.

In fact, according to an estimate from the Metropolitan Water District of Southern California, the amount of electricity used to deliver water to residential customers in Southern California is equal to one-third of the total average household electric use in Southern California.

usually also have hydroelectric generators that recover some of this energy as the water falls down the other side of those hills and mountains.

▶ *Water treatment:* Water treatment facilities use energy to pump and process water. The amount of energy required for treatment depends on source-water quality. High-quality groundwater may require little treatment; surface water taken from rivers that have upstream discharges of wastewater may require significant treatment. The energy required for water treatment is expected to increase over the next decade as treatment capacity expands, new water quality standards are put in place, and new treatments are developed to improve drinking water taste and color.[9] Agricultural water generally is not treated before use.

▶ *Local water distribution:* Energy is typically required for local pumping and pressurization, but gravity pressurization and distribution are also possible when reservoirs are sufficiently higher than residences and businesses.

▶ *End uses:* Water users consume energy by further treating water (e.g. with softeners or filters), circulating and pressurizing it (e.g. with building circulation pumps or irrigation systems), and heating and cooling it.

▶ *Wastewater collection and treatment:* Treating wastewater consumes energy in pumping, aeration, and other processes. In 1995, wastewater treatment in California used approximately 1.6 billion kWh of electricity.[10]

## ENERGY AND WATER USE: A CYCLE OF ENVIRONMENTAL DAMAGE

The development of the American West was facilitated by the construction of large water projects to convey water for municipal and agricultural uses. These water projects have brought important benefits, but they have also had well-documented and devastating impacts on rivers and landscapes throughout the West. Many once abundant species are now threatened or endangered due in part to these projects. When you include the massive energy production needed to operate these water projects, their environmental impacts are even greater. As one of the largest consumers of energy in the state, California's water system significantly contributes to the state's energy-related pollution.

Energy production has a wide range of damaging environmental and health effects, depending on how and where that energy is produced. Electric power plants, for instance, release dangerous levels of soot and smog, causing thousands of premature deaths, hundreds of thousands of asthma attacks, and other illnesses each year. In addition to the frequently noted air quality impacts of electric power plants, many power plants have once-through cooling systems that can significantly harm ocean and river environments. According to the Hudson Riverkeeper, a typical power plant using once-through cooling technology can kill billions of fish each year by trapping fish against intake screens or drawing fish into the facility.[11] Hydroelectric power production has far less impact on air quality, but far more negative effects on rivers and the aquatic species they support.[12]

## THE WATER-ENERGY-CLIMATE-CHANGE FEEDBACK LOOP

Energy production also leads to climate change. Power plants emit 40 percent of U.S. carbon dioxide pollution, the primary cause of climate change. Unless emissions are reduced, average U.S. temperatures could be 5 to 10 degrees Fahrenheit higher by the end of the century. Climate change has the potential to greatly affect water supply and water management. In California, climate change is likely to lead to greater risk of drought or water shortages in the summer months. At the same time, winter runoff may increase and cause a greater risk of flooding. [13]

All of these changes could have serious consequences for hydroelectric power generation. Changes in runoff have a direct impact on the amount of hydropower generated both because hydropower production decreases with lower flows and because higher flows often must be spilled past dams without producing any power. During droughts, there are two types of hydroelectric losses: less water runs through the turbines in powerhouses, and the lower reservoir level reduces the "head," thereby reducing the power produced by a given amount of water. In the Colorado River's lower basin, a 10 percent decrease in runoff reduces hydropower production by 36 percent.[14] As hydropower generation decreases, energy users are likely to turn toward fossil fuels, thereby increasing emissions that contribute to climate change. During the first five years of the 1987 to 1992 California drought, hydropower losses cost California ratepayers $3 billion and led to an increase in greenhouse gas emissions of 25 percent over normal levels.[15]

## ENERGY AND WATER SUBSIDIES: THE DRIVING FORCE BEHIND INEFFICIENCY

Despite the significant environmental and health concerns caused by energy intensive water use, many current policies actually encourage this wasteful practice. Energy and water subsidies in particular help drive the cycle of inefficient and energy intensive water use by hiding the true resource costs.[16] Water subsidies increase demand for water (thereby increasing energy use) and discourage conservation. Energy subsidies encourage transporting water over distances and pumping groundwater from depths that would not be economically feasible if the water users had to pay all the costs of energy and water. Policies aimed at reducing the energy used in water supply should address these inappropriate financial signals.

Subsidies exist when prices charged do not cover the government's cost or when the price does not equal comparable market price. A 1992 report from the Department of Energy's Energy Information Administration calculated the estimated subsidy value from these two different perspectives on federal hydropower sales nationwide. The report concluded that the annual subsidy at historic cost with full cost recovery was $1.232 billion for the Bonneville Power Administration (BPA) and $505 million for the Western Area Power Administration (WAPA) in 1990. The subsidy at estimated market price of electricity was $213 million for the BPA and $1.2 billion for the WAPA.[17]

Federal power remains close to the cheapest power in any region of the country.[18] Users of federally supplied irrigation water with access to this cheap power are getting

**POWER ARBITRAGE: MAKING A PROFIT OFF SUBSIDIES**

The schemes enabled by subsidized power rates can be seen in the Bureau of Reclamation's Columbia Basin Project. The project sells power to irrigators for less than 4 percent of the market rate. To take advantage of this cheap power, some water districts in the CBP have added low-head hydropower generators to their water canals. The cheap energy used to pump water into the canals is then used to help generate hydropower that the irrigators sell at a substantial profit on the open market. According to a report by the Committee on Natural Resources, this practice reduces water conservation incentives even further because every drop of water added to the canals provides more hydropower profits for the district. By allowing what is essentially a power arbitrage scheme, the Bureau of Reclamation has created an incentive for intensive pumping, leading to excess water and energy use and unnecessary environmental impacts, all at the taxpayers' expense.

a double subsidy and are receiving a distorted price signal about the value of that energy. For the Central Valley Project, energy charges vary widely from contractor to contractor. A charge of 1 cent per kWh—which a Central Valley Project representative estimated was the average for the project—is equivalent to $10 per MWh.[19] In comparison to market rate, California has long-term energy contracts for $86 per MWh.

It is difficult to calculate the full value of the subsidies given to users of federally supplied irrigation water. This difficulty helps keep the energy costs of water systems buried. Many California farmers still pay the government $2 to $20 per acre-foot for water, which represents as little as 10 percent of the "full cost" of the water, although some farmers are paying more as contracts are revised (e.g., $35 per acre-foot).[20] For new projects built or proposed by the Bureau of Reclamation, water costs are between $250 and $500 per acre-foot.[21] These water and power subsidies can have perverse results, as illustrated in the box on power arbitrage.

*Including energy considerations might eliminate some of the water supply projects currently being considered in California and would more accurately show the benefits of conservation as an alternative.*

## MISSED OPPORTUNITIES: WATER POLICY OVERLOOKS ENERGY USE

Resource management could improve if water planning and policy reflected the critical link between water and energy. Despite a few recent efforts, however, water planning at the federal, state, and local levels has largely failed to consider energy implications. CALFED, California's Bulletin 160 series, the California Urban Water Management Planning Act, and the Memorandum of Understanding Concerning Urban Water Conservation in California (MOU) all give inadequate attention to the connections between water and energy use and policy. Although CALFED and other agencies have completed many studies that compare the costs of different water supply options, few of these studies have taken into account the energy benefits and costs of different water supply options. This is unfortunate because energy cost is a critical factor in the cost of various water management alternatives. Including energy considerations might eliminate some of the water supply projects currently being considered in California and would more accurately show the benefits of conservation as an alternative.

Water planners at the state level also have done a very limited job of addressing energy considerations. The California Water Plan, known as Bulletin 160, updates information about current and future water supplies and water uses for all regions of the state, including an evaluation of possible options for meeting California's future water needs. The California Water Code requires that the Department of Water Resources update Bulletin 160 every five years. As recently as 1998, Bulletin 160 did not include energy considerations.

A draft of the 2003 California Water Plan was released in November 2003. For the first time, the water plan included a discussion of the impacts of global climate change on California water resources and policy. It also qualitatively considered energy prices as a factor that could affect future water use, supply, or management. Significant quantitative evaluation of energy issues was not included in the 2003 draft. Phases 2 and 3 of the update (scheduled for 2004 and 2005, respectively) might address energy issues in more detail, with quantification or modeling possible in Phase 3 (2005).

Water planning at the local level generally fails to integrate energy considerations. Under California's Urban Water Management Planning Act, every supplier of urban water to more than 3,000 customers or in quantities greater than 3,000 af/yr must adopt an Urban Water Management Plan and must update it at least every five years. The law requires that the plans contain fairly specific projections of supply, demand, and potential water conservation measures across a 20-year planning horizon. Completed plans are filed with the Department of Water Resources. The Urban Water Management Planning Act does not require water suppliers to consider the energy implications of their water management options or to factor in related energy costs and benefits when considering water conservation measures.

Most major urban water suppliers in California have committed to implementing a series of water conservation practices outlined in an MOU. The cost-benefit analysis required in the MOU does not require consideration of energy, so water suppliers may fail to implement conservation practices that are clearly cost-effective when energy is included (see Table 5 in Chapter 2 for some residential examples of this problem).

Finally, the California Environmental Quality Act requires suppliers to evaluate the potential environmental impacts of all projects, including water transfers such as the recent arrangement between the Imperial Irrigation District and the San Diego County Water Authority. But the energy implications of water decisions are so far below the radar of decision makers that the significant energy impacts of the transfer are not mentioned in the environmental impact report for the project.[22]

CHAPTER 2

# THE CONNECTIONS BETWEEN WATER AND ENERGY

NRDC
THE EARTH'S BEST DEFENSE

ENERGY DOWN THE DRAIN

*The Hidden Costs of California's Water Supply*

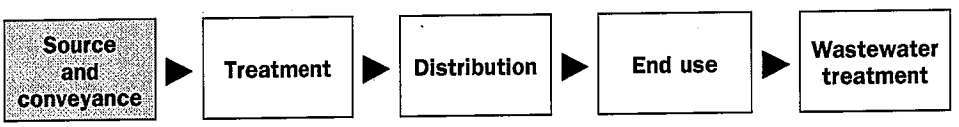
August 2004

As water works its way from source to tap, it typically requires many infusions of energy. We need energy to move it from its source, treat it, pipe it into businesses, consume it in our homes, and treat it before disposal. While one step in this process might not require a lot of energy—using a low-flow toilet in Los Angeles, for instance—another step may consume a great deal of energy—transporting water 2,000 feet over the Tehachapi Mountains to Southern California.[23] It is only when we look at the energy consumed in the entire water cycle that we get a clear sense of how much energy is really at stake.

This kind of whole-system calculation is called energy intensity. Energy intensity is defined as the total amount of energy required to use a specific amount of water in a specific location.[24] Energy intensity takes into account each site-specific step in the water supply-use-disposal cycle: source and conveyance, treatment, distribution, end use, and wastewater treatment.

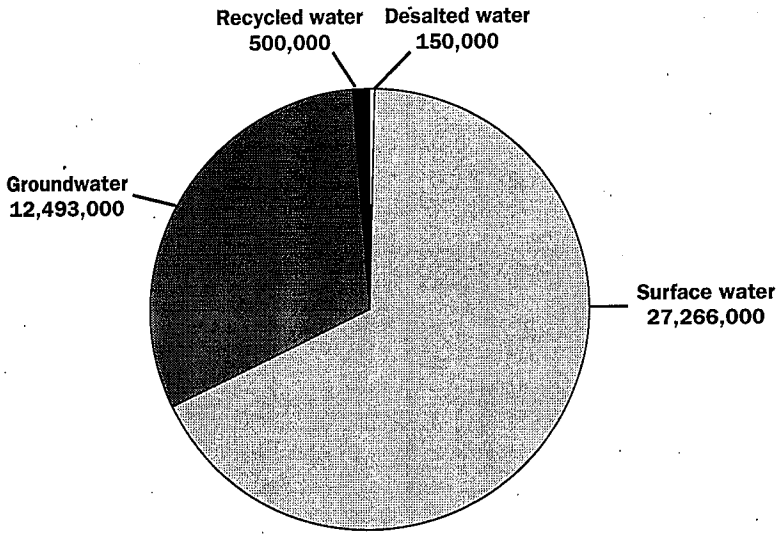
Looking at energy intensity reveals that not all water use requires the same amount of energy. For example, since it often takes more energy to convey a gallon of water from outside the region to Southern California than it does to Northern California, saving water in Southern California can achieve greater energy savings. This in turn means that water supply options appropriate for one region of California may not be appropriate for another. To determine appropriate strategies, water planners need to understand and quantify the five components of energy intensity presented below.

## SOURCE AND CONVEYANCE




California gets its water from a great variety of sources and locations, and each one relies upon a different method of transport and a different amount of energy use. California's water supply mix is illustrated in Figure 1.[25] At present, surface water and groundwater provide the primary sources of water supply in California. Use of

**FIGURE 1**
**Primary Sources of Water in California in Acre-Feet per Year**




desalination and water recycling is expanding and could impact the energy used for water supply in some regions.

### *Surface Water*

Surface water makes up about 70 percent, or about 27.3 million acre-feet per year, of water use in California. The majority of precipitation falls in the northern part of the state, while the majority of the population and the majority of water use is in the southern part of the state. Table 1 lists the major projects that transport water from one region to another in California.

These water delivery systems also generate hydroelectric power as water flows through power-generating turbines. Major water conveyance systems are either net energy producers (e.g., Central Valley Project, San Francisco, and Los Angeles aqueducts) or net energy consumers (e.g., State Water Project, Colorado River Aqueduct).

**TABLE 1**
**Major Water Projects and Water Deliveries in California**

| Project | Average Annual Deliveries (million acre-feet) |
|---|---|
| Central Valley Project | 7 |
| All American and Coachella Canals | 3 |
| State Water Project | 2.3 |
| Colorado River Aqueduct | 1.2 |
| Mokolumne Aqueduct | 0.36 |
| Hetch Hetchy Aqueduct | 0.33 |
| Los Angeles Aqueduct | 0.2 |
| Potter Valley Project | 0.154 |

Source: Association of California Water Agencies and Potter Valley Project Overview

### The State Water Project and the Central Valley Project

The State Water Project (SWP) and the Central Valley Project (CVP) are two of the largest water projects in California and convey water the longest distances. The single largest user of energy in California, the SWP consumes an average of 5 billion kWh/yr, accounting for 2 to 3 percent of all electricity consumed in California.[26] On average, pumping one acre-foot of SWP water to Southern California requires approximately 3,000 kWh (this is an average net energy use figure; actual energy use varies for different Southern California communities).[27]

State and federal operations staff for the SWP and the CVP are well aware of the energy used to move water and have long worked to minimize it. The large energy requirements of the SWP were recognized even prior to its construction. Early SWP plans called for a dedicated nuclear power plant to provide electricity for the lift over the Tehachapi Mountains. Since then, some activities, including operational changes at the Oroville Dam and the Thermalito Afterbay, have been designed to reduce power use.

Both the SWP and the CVP have large financial incentives to reduce energy use. For example, the average SWP annual operating budget is about $900 million, of which at least a third is related to power costs.[28] Efficiency measures implemented by facility operators include:

- *Early water projections and energy purchases:* Each water year, the SWP makes projections for its water deliveries and develops its energy portfolios to ensure it has enough power to make these projected deliveries. Buying the power early in the water year is critical: the SWP makes advance purchases (days, weeks, or months ahead) on the power market because they are much more economical than buying on the spot market.

- *Optimizing pump scheduling:* The energy costs for water systems depend heavily on whether energy is consumed during on-peak or off-peak periods. On-peak energy is significantly more expensive than off-peak energy. Within system constraints, the SWP and the CVP try to take advantage of the price difference by pumping off-peak and generating on-peak.

- *Engineering, repairs, and maintenance:* CVP and SWP representatives say that their projects are constantly refurbishing the system to maximize power generation and minimize power use. This includes evaluating the efficiency of pumps and generators and upgrading technology.[29]

Despite these efforts at energy savings, the CVP and the SWP may become even bigger energy consumers, since both are now considering building new and expanded dams. Our analysis indicates that these new or expanded facilities are likely to be net energy consumers (see the "Can Building New Hydroelectric Dams Consume Energy?" box on page 10 for further discussion of this issue).

### Conveyance and Evaporative Water Loss

Water is lost throughout the storage and conveyance process, often through evaporation and seepage as it sits in reservoirs and then travels through canals to water users.

**CAN BUILDING NEW HYDROELECTRIC DAMS CONSUME ENERGY?**

The Department of Water Resources and the Bureau of Reclamation are currently investigating five proposed new and expanded surface storage facilities to determine if they are feasible water supply projects. Proponents have cited hydropower production as an additional benefit for some of these projects. Careful analysis, however, reveals that these proposed dams might in fact be net consumers of energy.

Planning agencies often overlook two important energy-related issues regarding new and expanded dam projects: the first is off-stream location. Several of the facilities under consideration (Sites, Los Vaqueros, and some of the proposed sites on the Upper San Joaquin River) are off-stream facilities—constructed not on major streams, but in side canyons. These projects would require pumping water uphill into the reservoir. Energy would be generated when water is released from storage, but each of these facilities would be a net consumer of energy. Another of these proposed projects, the Delta Wetlands project, would be constructed on subsided delta islands. In this case, gravity would fill the reservoir, but energy would be required to pump water back into delta channels and deliver it to the SWP or other users. This facility would also be a net energy consumer.

The second often-overlooked issue is the amount of energy required to deliver the water generated by these new storage facilities. The water generated by new surface storage facilities could go to many water users. The closest potential user, Central Valley agriculture, however, will not be able to afford water from these facilities unless it is highly subsidized.

The other biggest market opportunity for the water is Southern California. But SWP water delivered to Southern California is very energy intensive, with a weighted average requirement for delivery of 2,947 kWh/af.[30] This energy requirement is so great that the energy required to convey this water would exceed the energy generated at the new dam. For example, one of the proposed expansions includes raising Shasta Dam. This is the best-case scenario since it would generate more new energy per acre-foot of additional storage than any other surface storage facility under consideration, both because Shasta is an on-stream reservoir that does not require pumping to fill the reservoir and because raising an existing reservoir generates more hydraulic head than a similarly sized new reservoir. Nevertheless, our analysis suggests that if the yield were delivered to Southern California, this project would result in a net consumption of 380 kWh/af.* In summary, all of the surface storage facilities under consideration by CALFED would be net consumers of energy if the water they generate were delivered to Southern California.

* See Larry Dale, et. al., *The Impact of Electricity Prices on the Cost of Five Options to Increase Southern California's Urban Water Supplies*, prepared for NRDC, 2003.

These losses increase the effective amount of energy required per usable gallon of water. Reservoir losses are not critical from an energy perspective when the reservoir is filled by gravity. But they may be critical if pumping takes place upstream of the reservoir (e.g., the Eastside Reservoir in Southern California) or if pumping is required to fill the reservoir, as in many of the current proposals for off-stream storage in California.

Reducing losses from reservoirs and conveyance systems could add to the available water supply and could generate additional hydroelectric energy. Reducing these losses would also lower the energy intensity of water supplies because it would

decrease the amount of energy used to transport water that is eventually lost (carriage water). The SWP has not done an analysis of conveyance losses but estimates these losses to be 5 percent.

The CVP has not done an analysis of its evaporative losses either. Instead, its models use assumed conveyance losses for evaporation and seepage south of the delta. CVP operations assume a loss of 150,000 acre-feet out of 3 million acre-feet delivered, or approximately 5 percent.

When comparing imported water to other sources, such as recycling or desalination, a full energy accounting would include the energy required to move water to the point where it evaporates or seeps out of the conveyance system. This energy would be added to the energy required to transport the water actually delivered.

### *Groundwater*

Groundwater represents about 30 percent of the water used in California, or approximately 12.5 million af/yr. This is 1.5 million acre-feet more than is naturally replenished, a pattern referred to as overdraft. Agriculture uses 85 percent of the withdrawn groundwater, and municipal areas use 15 percent. Most is used locally in the area overlying the aquifer.

California does not measure or regulate groundwater withdrawals, so groundwater data are incomplete. Therefore, it is not possible to calculate exactly how much energy is used in pumping groundwater. The California Department of Water Resources has estimated groundwater use and well depths in three areas that represent two-thirds of the groundwater used in the state. In the Tulare Lake Basin, with an average well depth of 120 feet, groundwater pumping requires 175 kWh/af. In parts of the San Joaquin River Basin and the Central Coast region where groundwater depth is closer to 200 feet, pumping requires approximately 292 kWh/af. Based on these estimates, electricity used for pumping groundwater in these areas would average 2.25 billion kWh/yr at a 70 percent pumping efficiency.[31] If this represents two-thirds of the state's groundwater use—and if all groundwater were pumped with electricity—then statewide electrical energy use for groundwater pumping would be approximately 3.4 billion kWh/yr.

In some areas, greater depth to groundwater requires even greater energy use. For example, pumping in Los Angeles requires 580 kWh/af.[32] Staff of the Sweetwater Authority and the Yuima Muncipal Water District in San Diego County report 467 and 661 kWh/af, respectively, are used on average to pump groundwater in their service areas (see Chapter 3). Staff of the Westlands Water District report that groundwater pumping in the district requires an average of 740 kWh/af (see Chapter 4).

Groundwater overdraft is a growing issue in some agricultural areas, like the Central Valley. As groundwater levels decline, an increasing amount of energy is needed to lift that groundwater to the surface. Jointly managing surface and groundwater resources, known as conjunctive use, holds promise as an approach to increasing water supplies in the West. Any analysis of conjunctive use projects must recognize and include the energy costs of retrieving the stored water from groundwater basins. However, if conjunctive use helps to recharge overdrafted

groundwater basins, it could decrease the average use of energy for pumping groundwater. The California Energy Commission has expressed serious concerns about the CALFED conjunctive use proposals and CALFED's inattention to their energy implications.[33]

### *Desalination*

Ninety-seven percent of the earth's water is too salty to drink or grow crops. However, salt water can be converted to freshwater through a process called desalination. Desalination has been limited in the United States because of its high cost: less than 1 percent of California's current water supply comes from desalination. However, it is a topic of growing interest as technological advances are reducing desalination costs.

The economics of desalination are directly tied to the cost of energy: energy constitutes approximately 40 percent of total costs. There are various methods of desalination, each requiring different amounts of energy. Energy use can vary within methods as well, depending on source water quality and design details.

The most common choice for new desalination plants today is reverse osmosis, in which salty water is filtered under high pressure through a semipermeable membrane. This method accounts for 90 percent of California's current desalination capacity. In 1999, desalination capacity in California was estimated at approximately 150,000 af/yr in more than 150 plants, the majority of which are small industrial plants. The 30 plants that are used for municipal purposes total about 80,000 af/yr.[34]

There are currently about two dozen desalination facilities proposed for along the California coast, with a total output of about 220,000 acre-feet.[35] The California Energy Commission is compiling data to determine how the energy demands of these proposed facilities could affect the state's power grid.

Current energy requirements and total costs for desalination vary widely depending on project specifics. For a seawater desalination plant under investigation by the Municipal Water District of Orange County, energy requirements are estimated at 5,500 kWh/af. The Carslbad seawater desalination project in San Diego County is estimated to use 5,400 kWh/af (see Chapter 3). Even lower energy use may be possible. Staff of Ionics Corporation report the new Trinidad seawater desalting plant will use about 4,800 kWh/af.[36] A proposed seawater desalting plant serving the Inland Empire Utilities Agency would use approximately 4,400 kWh/af.[37]

One of the models for lowering energy costs for desalination is colocating facilities with coastal power plants. Many of these power plants have destructive once-through cooling systems, however, and desalination should not be used to justify extending the life of these harmful facilities. In order for desalination projects—including colocated facilities—to gain acceptance, they will need to demonstrate a net reduction of environmental impacts.

Another opportunity for reducing energy requirements is to use desalination to treat brackish groundwater, which can produce water at a lower total cost and a lower energy cost than ocean desalination. Brackish groundwater treatment has enormously varying energy requirements depending on source water quality. Desalting brackish groundwater at the Chino Desalter Facility requires 1,700 kWh/af, while

**CAN DESALINATION REDUCE ENERGY USE?**

While desalination is very energy intensive on a per-unit basis, in some cases the flexibility it allows may result in lower total energy use.

The Marin Municipal Water District faces such an opportunity. The district is considering a desalination facility that would replace part of its contract with the Sonoma County Water Agency. The agency contract requires the district to purchase Russian River water at times of the year in which the water is not needed, in a classic "use it or lose it" arrangement. While the pumping needed to import Russian River water consumes less energy than desalination on a per-unit basis, the district would be forced to buy much more of it than it would need to produce with desalination.

With desalination, the district could shift more to its domestic reservoir supply—the least energy intensive source—in most year types, with desalination available as a dry-year supplement. The district's use of desalination to address peak demands could reduce its overall energy use.

In a dramatically different approach, private companies can also cover the cost of building and operating desalination plants in return for long-term contracts that require water agencies to purchase large volumes of desalinated water. Many Southern California projects are taking this approach. This could require desalination plants to operate at maximum capacity in order to drive down the unit cost, which could increase energy and air quality impacts.

the Reynolds water treatment plant in San Diego County reports only 405 kWh/af for treating brackish groundwater (see Chapter 3).[38] The same technology can be used to clean up groundwater impaired by other contaminants.

While the process of desalination remains expensive as a water supply option, it can have a variety of potential benefits relative to other sources of supply, including:

▸ *Local supply:* Desalination is typically done close to the place of use, so energy requirements for conveyance are likely to be lower than they would be for imported water supplies.

▸ *Reliability:* Desalination makes water available in all water years, while surface water and groundwater supplies may be limited in dry years. This reliability is extremely valuable to urban water users.[39]

▸ *Operational flexibility:* If the water is not needed, a desalination facility can be turned off. This is in contrast to the take-or-pay provisions of some water contracts. For the advantages and potential pitfalls of this approach, see the box on desalination above.

▸ *Water quality:* Desalination can produce very high-quality water, required by some water districts for blending with some of their lower-quality water supplies.

▸ *Potential ecosystem benefits:* Leaving surface water supplies instream and using desalinated water as a partial replacement can generate substantial ecosystem benefits.

Desalination may be a reasonable part of a water supply plan in areas where the energy costs of importing more supplies are high and where alternative water

*Desalination makes water available in all water years, while surface water and groundwater supplies may be limited in dry years. This reliability is extremely valuable to urban water users.*

sources could be environmentally damaging. This is particularly true when full life-cycle energy costs are considered along with the benefits of desalination, such as reliability, ecosystem restoration, and water quality.

However, before moving forward with desalination on a large scale, districts must recognize that very little is known about its impact on marine and coastal environments. Few, if any, studies have been conducted on marine resource impacts from the large-scale desalination facilities in the Middle East and Caribbean. The range of potential adverse environmental impacts that may arise from desalination facilities include siting and construction, waste discharge, energy consumption, coastal development, and injury and death of aquatic life from water intakes.[40] These must all be explored and adequately addressed before development of desalination facilities begins. In most cases, conservation or water recycling may offer better, cheaper, and less environmentally damaging alternatives.

*In most cases, conservation or water recycling may offer a better, cheaper, and less environmentally damaging alternative to desalination.*

### *Water Recycling*

The California Water Code defines recycled water as "water which, as a result of treatment of waste, is suitable for a direct beneficial use or controlled use that would not otherwise occur."[41] By 2020 more than 3 million acre-feet of wastewater will be generated annually by California's urban coastal areas; much of this could be recycled.

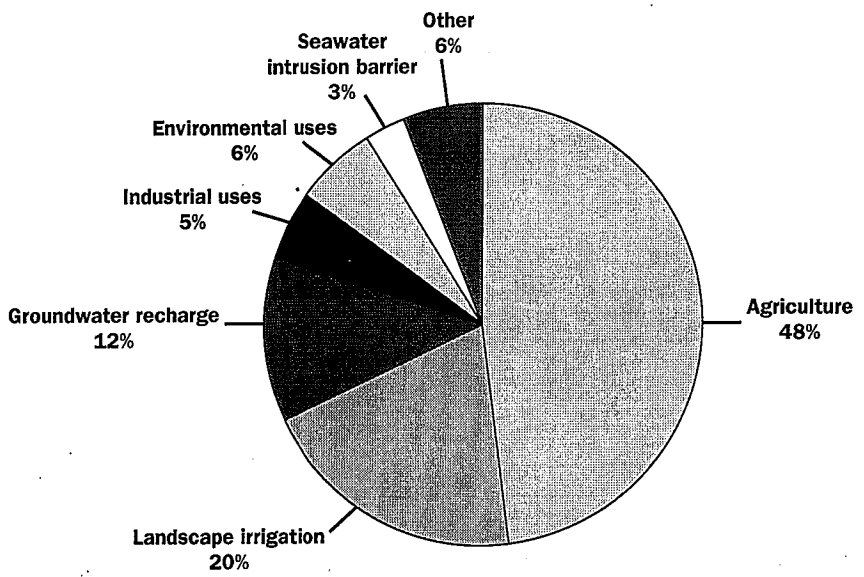
Recycled water is most commonly used for groundwater recharge or for landscape or irrigation purposes. While there have been some proposals for direct potable reuse of recycled water, these projects have not been implemented in the United States. Figure 2 shows municipal recycled water use in California in 2000.[42] Recycled water use is currently estimated to be within a range of 450,000 to 580,000 af/yr.[43] In addition to this officially recycled water, hundreds of thousands of acre-feet of treated wastewater are released into rivers and become part of the downstream water supply.

The energy costs for water recycling are the incremental treatment costs required to treat wastewater to the standard necessary for its intended use, and any energy required to convey the water to its place of use. Costs vary depending on the type of project being developed, the degree of treatment required, and the proximity of the water treatment plant to the location where the recycled water will be used.

In 2001, California legislation created a recycled water task force within the Department of Water Resources. The task force was assigned the responsibility of identifying impediments to using more recycled water in California, along with possible solutions. The task force's report was completed in June 2003 and asserts that California could recycle 1.5 million af/yr by 2030, with an investment of nearly $11 billion for additional infrastructure.[44]

Recycled water is already serving as an important element of water supply for many communities. As with desalination, water recycling offers reliability benefits, since it is available even in drought years. The energy costs for recycled water are likely to be lower than the costs for most other supply-side options, including desalination.

**FIGURE 2**
**Recycled Water Use in California in 2000**




*The energy costs for recycled water are likely to be lower than the costs for most other supply-side options, including desalination.*

The Orange County Water District is constructing a groundwater replenishment system—a water-recycling system that will replace an existing Orange County water recycling facility and will provide a new water supply for the area. Water from the system will be used as a seawater intrusion barrier as well as to augment groundwater supplies. Water costs for that component of the district's supply will be reduced by nearly half, since it will be less expensive to treat as well as produce the water locally than to import water.[45] In particular, producing the recycled water will require only half the energy it takes to bring water to Orange County from Northern California.[46] The system is expected to begin delivering water in 2007.

A few other examples of the many water recycling projects in California include:

- A joint project of the Dublin San Ramon Services District and the East Bay Municipal Utility District, in which 2,800 acre-feet of recycled wastewater are used to recharge the aquifer annually;

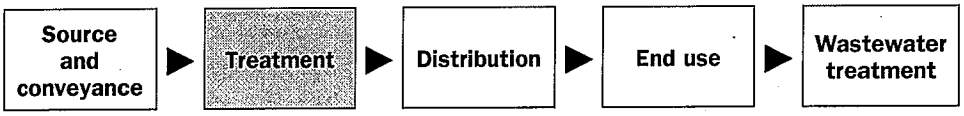
- South Bay and Long Beach, where recycled water is injected into formations that are part of the basin's aquifers to prevent seawater intrusion;

- Los Angeles County, where the Central Basin Recycled Water Project delivers approximately 4,000 acre-feet annually to more than 150 industrial, commercial, and landscape irrigation sites;

- South Bay Water Recycling in San Jose, which delivers around 16,000 af/yr to landscape irrigation customers;

- Monterey County Water recycling projects that provide recycled water for agricultural irrigation.

## TREATMENT




Treatment is the second stage in the water use cycle, and generally applies only to urban water. The average direct electricity requirement for surface-water treatment plants is 450 kWh/af, with the bulk of that energy going to pump treated water.[47] Since pumping costs are directly related to the volume of water that must be pumped, reductions in demand for treated water will directly reduce this energy use. Energy efficient pumping systems can also make a significant difference in power bills and can reduce demand on energy infrastructure. Opportunities include installing premium efficiency motors and adjustable speed drives, selecting efficient pumps, using effective instrumentation and controls, and managing pumping operations by the efficient use of available storage and highly efficient pumping units.[48]

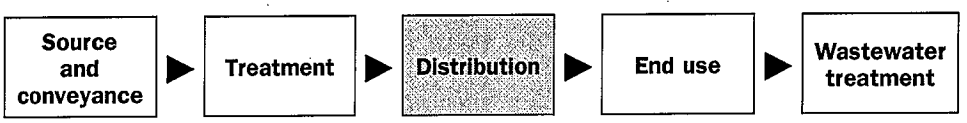
Data from the San Diego case study (see Chapter 3) confirm that energy for treatment is quite small. The Perdue Water Treatment plant reports using only 41 kWh/af; the Escondido-Vista plant reports 48 kWh/af; and the Levy Water Treatment Plant reports 68 kWh/af.

*By reducing peak demand, water conservation can eliminate or delay the need for expanding treatment facilities or decrease the size of the expansion needed.*

Most surface water sources require treatment, usually consisting of chemical additions, coagulation and settling, filtration, and disinfection. Urban water suppliers are moving in the direction of more energy intensive treatment methods of disinfection such as ozonation and ultraviolet radiation for health and safety reasons.[49] In many groundwater systems, disinfection is the only treatment required. Physical-chemical processes are used only in those cases where excessive concentrations of specific constituents have to be reduced.

Water treatment facilities are sized to meet peak demands. The lowest demand for water occurs in winter months when the requirements for outside water use are greatly reduced. Peak demand occurs in the summer when consumers irrigate for crops and landscaping. As mentioned in Chapter 1, many of the peak demands for water coincide with the peak seasonal demands experienced by the electrical utilities.[50] By reducing peak demand, water conservation can eliminate or delay the need for expanding treatment facilities or decrease the size of the expansion needed. By decreasing peak demands on the electrical utilities, water conservation can also help avoid power shortages.

## LOCAL DISTRIBUTION




Water systems must transport water from the intake source to treatment facilities, then to local storage facilities, and finally to the customer. Most of the energy

involved in municipal water systems is used for pumping. For a city of 50,000 people, approximately 2 million kWh/yr are required for all plant operations, with more than 1.6 million kWh of that amount needed for the pumping alone.[51] Assuming 2.6 persons per household and 0.5 acre-foot per household per year of water consumption, this pumping-only estimate converts to about 170 kWh/af delivered to customers.

These are average figures. In many cases, energy for pumping is much higher. According to members of the San Diego County Water Authority staff, there is enormous variation in the energy used to distribute water from their treatment plants to customers. Limited data from the San Diego case study support this belief. The Levy-Helix Water District, for example, reports an average of 215 kWh/af to deliver water to its customers; however, half the distribution grid is pressurized by gravity since some treatment plants are significantly elevated above end use locations. The electrically pressurized portion of their distribution system reportedly uses about 430 kWh/af. The distribution system for the North City (San Diego) water recycling facility reportedly uses about 940 kWh/af.

Many urban water distribution systems were placed underground more than 50 years ago, and leaks caused by corrosion of pipe material or other problems can lead to the loss of significant amounts of potable water. Distribution system losses increase the energy intensity of water supply by requiring utilities to treat and convey water that will be lost. Losses vary significantly among urban suppliers: typically from 6 to 15 percent, but as high as 30 percent.[52] Approximately 2 percent of this lost water goes to unmetered use for firefighting, construction, and flushing drains and hydrants.

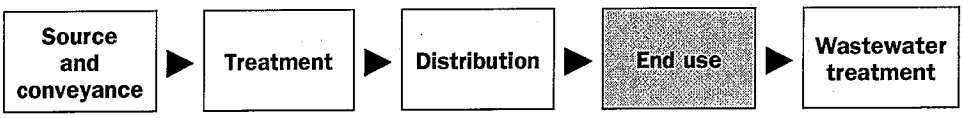
One approach to improving management of local distribution and reducing energy costs involves using a supervisory control and data acquisition (SCADA) system. The SCADA system consists of a central computer that integrates the operation of water-system control points, such as pumps, reservoirs, and metering stations, even when located far away from one another.

Fresno installed a SCADA system in 1988. The SCADA system saves Fresno $725,000 per year in energy and water costs by doing the following:[53]

- Continuously monitoring the pumping energy required for each gallon of water that every well produces;
- Turning on the pumps at the most cost-effective wells first;
- Selecting wells according to optimum time-of-day electrical rates;
- Providing better control of water-line pressure, which reduces leakage.

With the SCADA system continuously monitoring and managing the pumps, Fresno saves energy and money both by reducing the energy consumed by the pumps and by saving water that previously was lost to leakage. While many urban districts use SCADA systems, not all systems are being operated to reduce energy use. Some agricultural districts are also installing SCADA systems and variable frequency motor drives that are more efficient under partial loads, allowing them to save both water and energy.[54]

**THE END USE OF WATER**




Once a customer receives water, additional energy may be needed to heat, cool, purify, or pump that water in preparation for its intended use. Changes in the amount or quality of water needed for some of these uses can further increase the amount of energy consumed in the process. The literature on water use contains little information on energy use integral to water end use beyond domestic fixtures and appliances. The San Diego case study (Chapter 3) and to lesser extent the Westlands and Columbia case studies (Chapters 4 and 5) evaluate this issue to the extent possible given the resources available for this report. This is an area of great significance for future research and energy and water policy.

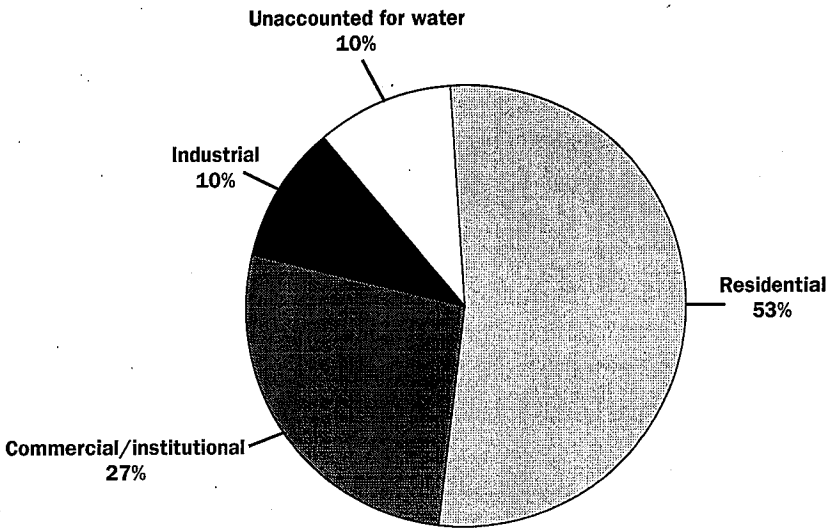
While there are efficiency improvements that can reduce the energy inputs required at each stage of the water use cycle, the greatest energy and water savings come from reducing water consumed by various end uses. Conservation at the end use stage eliminates all of the "upstream" energy required to bring the water to the point of end use, as well as all of the "downstream" energy that would otherwise be spent to treat and dispose of this water.

*Conservation at the end use stage eliminates all of the "upstream" energy required to bring the water to the point of end use.*

### *Urban Water Use*

California urban water use in 2000 was approximately 7 million acre-feet.[55] Urban use is typically divided into residential and nonresidential use, with nonresidential use further divided into commercial, industrial, and institutional uses (CII). The breakdown of urban water use in California is illustrated in Figure 3.

**FIGURE 3**
**Urban Water Use in California**



### *Residential Water Use*

California's residential sector uses almost 4 million af/yr. A new study found that approximately 1.4 million acre-feet of this use could be saved with existing cost-effective technologies.[56] These water savings would also provide substantial energy savings from avoided conveyance, treatment, distribution, end use, and wastewater treatment.

#### Hot Water Use

A study of 1,200 homes in 14 cities looking at residential water use found that the top four indoor uses were:[57]

- Toilet (26.7 percent);
- Clothes washer (21.7 percent);
- Shower (16.8 percent);
- Faucet (15.7 percent).

Energy use and savings from the latter three items on this list, which all use hot water, are presented in Tables 2 through 4.[58] Savings from toilets are discussed separately below.

Conserving water from some hot-water-using devices may not be cost-effective when water savings are considered alone. But as Table 5 demonstrates, the measures are very cost-effective when energy savings are included.[59] Where the table indicates

**TABLE 2**
**Estimated Energy Use by Showerheads**

| | Rated Flow (gallons per minute) | Actual Flow (gallons per minute) | Estimated Energy Use per Household* (kWh/yr) | Estimated Savings per Household with a 2.5 gpm showerhead (kWh/yr) |
|---|---|---|---|---|
| 1994–present | 2.5 | 1.7 | 1,128 | |
| 1980–1994 | 3.0 | 2.0 | 1,328 | 200 |
| 1980–1994 | 4.0 | 2.7 | 1,793 | 665 |
| Pre-1980 | 5.0–8.0 | 4.3 | 2,855 | 1,727 |

*Assumes 5.3 minutes per person per day; 2.64 persons per household; 0.13 kWh of electricity per gallon of water at 106 degrees.

**TABLE 3**
**Estimated Energy Use by Faucets**

| | Rated Flow (gallons per minute) | Actual Flow (gallons per minute) | Estimated Energy Use per Household* (kWh/yr) | Estimated Savings per Household with a 1.5 gpm Faucet or Aerator (kWh/yr) |
|---|---|---|---|---|
| 1994–present | 1.5 | 1.0 | 445 | N/A |
| 1994–present | 2.5 | 1.7 | 756 | 311 |
| 1980–1994 | 3.0 | 2.0 | 890 | 445 |
| Pre-1980 | 3.0–7.0 | 3.3 | 1,468 | 1,023 |

*Assumes 8.1 minutes per person per day; 2.64 persons per household; 0.057 kWh per gallon of water at 80 degrees.

**TABLE 4**
**Estimated Energy Use by Clothes Washers**

| | Water Use (gallons per minute) | Energy Use (kWh per load) | Estimated Energy Use per Household* (kWh/yr) | Estimated Savings per Household with a 27 gpm Clothes Washer (kWh/yr) |
|---|---|---|---|---|
| 1998–present | 27 | 1.6 | 632 | N/A |
| 1990–present | 39 | 3.0 | 1,185 | 553 |
| 1980–1990 | 51 | 3.9 | 1,540 | 908 |

*Assumes 0.41 loads per person per day; 2.64 persons per household. Applies only to households with clothes washers.

**TABLE 5**
**Accounting for Energy Benefits from Indoor Residential Water Conservation**

| | COST OF CONSERVED WATER (DOLLARS PER ACRE-FOOT CONSERVED) | |
|---|---|---|
| **Device Installed (natural replacement)** | **Without Energy Benefit** | **With Energy Benefit** |
| 2.5 gallon-per-minute showerhead | $324 | –$736 |
| Average high-efficiency clothes washer (includes vertical and horizontal axis machines) | $865 | –$177 |
| Average high-efficiency dishwasher | $862 | –$102 |

negative costs of conserved water, energy savings alone more than pay for the conservation investment.

Federal and state programs to promote market transformation, along with state and local rebate programs, can accelerate the adoption of these technologies.[60]

### Cold Water Savings

Toilets and landscaping account for the two largest residential uses of water. Both use cold water and do not require significant end use energy. However, conservation of cold water can still save upstream and downstream energy inputs. Pacific Gas & Electric estimates that conveyance, treatment, distribution, and disposal energy requirements average 1,788 kWh/af statewide.[61] These requirements are much higher in Southern California, where conveyance alone averages close to 3,000 kWh/af.

Toilet flushing represents the largest single use of water inside the home. While older toilets use as much as 6 gallons per flush, federal and state water-efficiency laws now standardize flush volumes at a maximum of 1.6 gallons per foot for all new toilets. Many water utilities in California have conserved significant quantities of water by installing ultra low-flow toilets. Statewide, however, there are significant additional savings still available from ultra low-flow toilet retrofits.[62] Ultra low-flow toilets do not save end use energy because toilets don't use hot water, but they can save conveyance, distribution, and treatment energy.

Landscape water use represents approximately 40 percent of residential use in California. A recent study estimates that California residents could save from

25 to 40 percent of their landscape water use by improving management practices and applying already existing technology, such as rainwater cisterns and gray-water systems that reuse household wastewater for irrigation. These savings could be achieved relatively quickly and would reduce water use by 360,000 to 580,000 per year.[63]

One potentially effective way to target landscape water use is through rates. More than 2 million California residents are charged a fixed rate for water usage. This system fails to reward those who conserve and punish those who waste. Fixed rates are usually used when meters have not been installed. Lack of meters in turn allows leaks to go undetected. Data show that per-capita water use is about one-third less in areas where water users are billed based on volumetric rates rather than fixed rates. Metering is one of the most basic and effective water conservation tools. Recent legislation requires some unmetered cities in California to install water meters and bill water users on the basis of water use, and proposed legislation (AB 2572, Kehoe) would address the remaining unmetered cities.

### Commercial/Industrial/Institutional Water Use

California's commercial, industrial, and institutional (CII) sector accounts for more than 30 percent of urban water demand, or around 2.5 million acre-feet.[64] More than 50 percent of the total CII water use is for cooling and heating, which requires energy inputs.[65] Recent studies estimate that cost-effective conservation could reduce CII water use by 15 to 50 percent.[66] In California, a recent study estimates that the CII sector could save 39 percent of the water it uses, which would correspond to statewide savings of 1 million acre-feet.[67]

*Data show that per-capita water use is about one-third less in areas where water users are billed based on volumetric rates rather than fixed rates.*

Commercial customers often have the same water needs as residential users, e.g., toilets, sinks, laundries, kitchens, and landscaping. The most frequently used commercial conservation measures include plumbing fixtures and appliance retrofits or replacement and more efficient landscaping. Institutional customers, such as schools and universities, hospitals, government buildings, prisons, and military installations, primarily use water for heating and cooling, domestic uses, and landscape irrigation.

Industrial water use primarily falls into five categories:

- Cooling and heating
- Industrial processing
- Washing
- Adding as a direct ingredient
- Landscaping

Data on water-related energy use in industry are scant. The Department of Energy asks manufacturers to report energy information on many end uses, but water treatment (e.g., heating, cooling, treating water) is not one of the end uses. Instead it gets embedded into broader end use categories. This makes it difficult to estimate industrial water-related energy use.

The most common conservation measures used in the industrial sector include site-specific engineering modifications of water-using equipment and processes.[68] Despite the potential for large savings in the CII sector, a study done for the American

**DISHWASHERS AND WASHING MACHINES: HOW AN INCREASE IN ENERGY INTENSITY CAN STILL LEAD TO OVERALL ENERGY SAVINGS**

Energy intensity measures the amount of energy used per unit of water. Some water sources are more energy intensive than others; for instance, desalination requires more energy than wastewater recycling. Water conservation technology may either increase or decrease energy intensity.

Yet when water planners make decisions, they should look not just at energy intensity, but also at the total energy used from source to tap. In the case of water conservation, some programs may consume a lot of energy at one stage in the energy-water-use cycle, but still decrease the amount of energy used overall. The following three examples illustrate the interplay between energy intensity and total energy use.

**Water conservation may increase energy intensity and increase total energy use.** A particular irrigation technology could reduce water use by 5 percent, but require so much energy to operate that it increases the energy intensity per acre-foot of water by 10 percent. This could increase total energy use by 4.5 percent.

**Water conservation may increase energy intensity and decrease total energy use.** The average high-efficiency dishwasher increases the energy intensity of dishwashing by 30 percent, but it reduces water use by 34 percent. As a result of using less water—and therefore less energy to convey water from the source to the dishwater—the net total energy needed to wash dishes would decline by 14 percent.

**Water conservation may decrease energy intensity and decrease total energy use.** The average high-efficiency clothes washer reduces water use by 29 percent, as compared with average low-efficiency machines, and simultaneously lowers energy intensity by 27 percent. Energy intensity declines because mechanical aspects of the machines (agitators, etc.) are also improved. By reducing total water use and energy intensity, total energy use is reduced by 48 percent.

Water Works Association Research Foundation found that certain types of large water-using facilities such as correctional facilities, military bases, and utility systems have been ignored by many audit programs and have thus not received recommendations for conservation measures. The study further noted: "improved coordination and cooperation among water, wastewater, and energy utilities are needed to realize the water efficiency potential in the CII sector."[69]

Landscape water use represents the single greatest use in the CII sector. In 2000, 38 percent of CII water use in California was used for landscape irrigation.[70] A recent study estimates that it is possible to reduce this water use by 50 percent.[71] One important tool for achieving these savings is better management of landscape water use. Frequently, the same meter is used to measure a property's indoor and outdoor water use. In these complex mixed-use situations, it may be difficult to even know how much water is being applied to the landscape. Proposed legislation (AB 2298, Plescia) would require a dedicated landscape meter for new construction with more than 10,000 square feet of irrigated acreage and for existing properties with more than one acre of irrigated landscape. This would enable water agencies to establish water budgets for these large landscapes and to target landscape water waste with appro-

priate rate structures. Dedicated landscape meters would also enable landscape managers to better ensure the efficiency and proper functioning of irrigation systems.

### *Urban Conservation*

Since end use appears to consume the most energy in the water-supply-use chain, water conservation programs hold enormous energy conservation potential. Much of the urban water conservation occurring in California is driven by national and state efficiency standards for certain water appliances and by the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU)—an agreement signed by most of the large urban water suppliers in California outlining a series of water conservation best management practices. The MOU and the California Urban Water Conservation Council (composed of signatories to the MOU) deserve much credit for advancing urban water conservation in California.

Nevertheless, significant conservation potential remains beyond what the MOU requires.

- The MOU does not require agencies to implement all cost-effective conservation strategies, but rather specifies levels of implementation (i.e., percentage of customers to be audited or number of toilets to be replaced).

- The Urban MOU has minimal requirements for CII water use, demanding only that utilities survey and offer incentives to 10 percent of their CII customers, and to achieve 3 percent CII water savings through implementation of a CII ultra low-flow toilet program by 2004.

- Because the Urban MOU targets a limited number of customers for landscape audits, even full implementation of the MOU will probably generate only a small portion of these total potential landscape water savings.

- The MOU pays scant attention to energy. For example, MOU signatories are not required to include energy savings when determining if a best management practice is cost-effective.

The neglect is mirrored by the energy utilities, which pay little attention to saving water. The only water-saving elements typically included in energy conservation programs are those that save hot water. This is unfortunate because, as noted throughout this report, saving even cold water can save significant amounts of energy, depending on the source of that water.

Some energy utilities have noted the link between water and energy use and have targeted their public messages accordingly. Public education materials from the Sacramento Municipal Utility District note: "a tremendous amount of electricity is used to run the pumps that obtain, purify, and bring water to your house and then transport wastes to your regional wastewater utility. To help reduce this energy use, the Sacramento Municipal Utility District and the Sacramento Area Water Works Association ask that you avoid using large amounts of water during the peak energy demand hours of 11 A.M. to 7 P.M."[72] Unfortunately, this approach is still the exception.

In sum, while energy savings are possible at all stages of the water supply cycle, water conservation programs may be the most cost-effective way of reducing the total energy involved in urban water use. In particular, programs aimed at reducing water use in areas with energy intensive supplies may yield the most cost-effective water and energy savings.

### *Agricultural Water Use*

Agriculture uses approximately 80 percent of the developed water supply in California. In 1995, this amounted to almost 34 million acre-feet.[73] In 1995, California agriculture used approximately 4.4 billion kWh of electricity for groundwater pumping and irrigation purposes, and more than 11 billion kWh for all purposes.[74] Ninety percent of all electricity used on farms is used for groundwater pumping.[75]

For agriculture south of the delta, significant energy may be required for conveying surface water supplies, and reducing water use can translate into energy savings. For agriculture in some other regions of California, such as the Sacramento Valley, surface supplies are gravity fed and reducing surface water use will not translate into saving conveyance energy. Yet even in these areas, improving water use efficiency may save energy by decreasing groundwater pumping and reducing energy required for local distribution. However, in some cases, energy savings from reduced surface water deliveries or reduced groundwater pumping may be partially or fully offset by increased energy requirements of some water-efficiency technology.

*Given the proper price signals—especially elimination of subsidies—farmers may shift to lower-water-use/higher-value crops.*

Improving the efficiency of irrigation systems through better water measurement and irrigation scheduling, installation of micro-irrigation systems, tailwater recovery systems, and other measures can reduce agricultural water use on farms. [76] In addition to improving irrigation efficiency, farmers can also reduce water use by shifting to lower-water-use crops. While crop choice is made based on a wide variety of factors, resource costs play a significant role. Given the proper price signals—especially elimination of subsidies—farmers may shift to lower-water-use/higher-value crops. For example, a 1992 California Energy Commission report to the state legislature found that agriculture's response to the seven-year drought and changes in energy rates "was to shift production from low-value to high-value crops (e.g., from alfalfa to tomatoes). Even with higher costs, the agricultural economy was robust and these high-value crops were able to absorb those costs."[77]

Dry years present a particular challenge for both water and energy systems: demands are greater while supplies are reduced. In dry years, water systems generate less power. Not only does less water run through the turbines in powerhouses, but also the lower reservoir levels reduce the water pressure and thus reduce the power produced by a given amount of water. Unfortunately, dry years tend to result in increased power demand. During dry years, water systems will need to pump more water—and therefore consume more energy—because irrigators (and other consumers) are getting less water from rainfall. Also, in low water years, farmers are more likely to rely on groundwater pumping, which increases the demand for power.

A voluntary program of compensated dry-year fallowing of agricultural lands could generate a substantial dry-year water supply. However, depending on the source and

disposition of the transferred water, these programs may not save energy. Quantified examples of the potential energy and water benefits or costs of permanent or dry-year land-retirement programs are provided in the Westlands Water District (Chapter 4) and Columbia Basin (Chapter 5) case studies. As discussed in the Columbia River Basin case study, such programs can provide significant benefits to the agricultural economy.

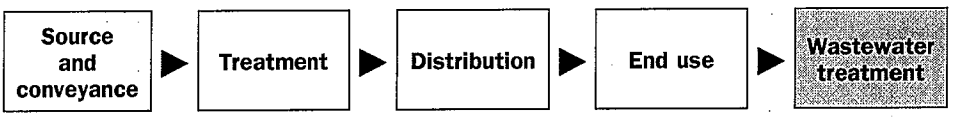
### *Agricultural Water Conservation*

California currently lacks a comprehensive program for agricultural water use efficiency. Agricultural water users established the Agricultural Water Management Council, which developed a list of best management practices, but environmental groups have been critical of the council's process because it fails to adequately address water measurement, and it relies on a purely voluntary approach. Only four water management plans were submitted to the council last year.

CALFED's efforts to develop an agricultural water-use efficiency program have also been a disappointment. CALFED staff worked with environmental and agricultural stakeholders and agency representatives to identify specific benefits related to water flow, timing, and quality that can be achieved through agricultural water use efficiency, and to establish quantifiable objectives for the portion those benefits for which agriculture should be responsible. This program could allow for inclusion of energy costs and benefits, although inclusion of energy costs is not currently required in the cost-benefit analysis that must be submitted with project proposals.

Unfortunately, the task of implementing the CALFED Agricultural Water-Use Efficiency Program has been passed on to the Department of Water Resources, where it languishes. Updating quantifiable objectives is supposed to be an ongoing process, yet no additional objectives have been developed or refined since the program was given to the department. There is no process in place for evaluating progress toward meeting quantifiable objectives. CALFED has not even initiated its required three-year evaluation of progress toward meeting quantifiable objectives. The program never adopted any enforcement mechanisms or consequences for not meeting the program objectives.

## WASTEWATER TREATMENT




Wastewater systems generally include three components: collection systems (sewers and pumping stations), treatment facilities, and effluent disposal or reuse. Collection and disposal or reuse require energy for pumping, while treatment requires energy for pumping, running treatment operations, and processing solids. In 1995, wastewater treatment in California used approximately 1.6 billion kWh of electricity.[78] Given California's continued growth, current energy use for wastewater treatment is likely to be significantly higher.

**TABLE 6**
**Energy Use in Wastewater Treatment**

| Treatment | 1-mgd facility (kWh/af) | 100-mgd facility (kWh/af) | 100-mgd facility with energy recovery (kWh/af) |
|---|---|---|---|
| Trickling filter | 580 | 225 | 130 |
| Activated sludge treatment | 750 | 340 | 225 |
| Advanced treatment | 865 | 400 | 280 |
| Advanced treatment with nitrification | 980 | 520 | 400 |

Estimates of the energy used in water treatment depend on facility size, type of processing, and efficiency. Some facilities (typically larger facilities) recover energy from biogas combustion, which reduces their net consumption. Average energy use is illustrated in Table 6.[79]

Frank Burton conducted a study computing a weighted average over the range of facility sizes and estimates the following net energy requirements: 440 kWh/af for activated sludge, 501 kWh/af for advanced wastewater treatment without nitrification, and 640 kWh/af for advanced wastewater treatment with nitrification. The study estimated that by 2008, 50 percent of U.S. wastewater treatment capacity would include nitrification.

Energy used for wastewater plants in the San Diego case study (see Chapter 3) ranged from 816 kWh/af for the Santee Basin plant to 1,272 kWh/af for the North City (San Diego) plant. Variation may be wider than these numbers suggest since all water from the Santee Basin plant is reused either in recreational lakes or for irrigation after treatment to tertiary standards.

Water conservation can reduce the energy required for treating wastewater and can eliminate the need for new or expanded facilities. The 1996 Clean Water Needs Survey submitted to Congress by the Environmental Protection Agency identified more than $139 billion in capital costs for water quality projects and other related work eligible for funding through state revolving funds established under the Clean Water Act. Close to $100 billion of this amount is flow-related and could be delayed or reduced through water conservation.

Water conservation can also reduce wastewater treatment operating costs. In Orange County, California, conservation-induced reductions in wastewater flows generated energy savings in collection systems pumping, influent pumping, aeration, and outfall pumping. Taken together, these energy savings amounted to $11,047 per year for each million gallons per day of reduced flow. These savings are equivalent to about $10 per acre-foot of reduced flow. Capital costs savings were estimated to be worth more than 10 times this amount for the Orange County system.[80]

## ADDITIONAL ENERGY IMPLICATIONS OF WATER POLICY

This chapter has focused on the energy embedded in water use—the energy directly applied during the five stages of the water use cycle through activities such as

pumping, heating, and cooling. However, the energy implications of water policy extend far beyond the energy embedded in water. For example, if a water allocation decision results in a factory closure, the factory would save both the energy embedded in water use and any other energy required for operating the facilities, such as heating, lighting, and industrial processing. The implications of a water policy decision may include changes in embedded energy use, as well as changes in other types of energy use.

In agriculture, water policy decisions may affect the amount of water applied to a field, and the energy required to obtain and apply that water. Savings from these changes represent the embedded energy component. In addition, water policy decisions that result in altered crop patterns may affect the amount of energy required for harvest, cultivation, and processing. These changes represent additional energy implications of the policy.

In situations where water for irrigation is diverted upstream of hydropower generation facilities, deciding to irrigate means deciding to forego hydropower generation. This lost hydropower generation is not included when calculating the amount of energy embedded in water, yet these hydropower opportunity costs are also energy implications of water resource decisions. (Chapter 5 explores these additional energy implications in the Columbia River setting.)

*Where water for irrigation is diverted upstream of hydropower generation facilities, deciding to irrigate means deciding to forego hydropower generation.*

This report has focused so far on energy embedded in water. But additional energy implications can be quite significant. While a complete analysis of the full energy implications of water policy decisions is beyond the scope of this report, for illustration purposes, we do analyze some of the additional energy implications of the specific water policy decisions discussed in the case studies.

NRDC
THE EARTH'S BEST DEFENSE

ENERGY DOWN THE DRAIN

*The Hidden Costs of California's Water Supply*

August 2004

CHAPTER 3

# SAN DIEGO COUNTY—ENERGY AND URBAN WATER

Like many California water agencies, the San Diego County Water Authority (SDCWA) is attempting to find additional water sources to meet its current and projected water demands. SDCWA staff estimate that at least an additional 100,000 af/yr of end use water will be required in 2020. Efforts to develop these supplies are well under way. However, analysis of supply alternatives historically has neglected consideration of energy implications. This chapter illustrates the type of results SDCWA would obtain if they analyzed supply choices from an energy perspective.

The preliminary results of our San Diego analysis indicate that:

- End use constitutes the largest component of energy embedded in the urban water-use cycle.
- Conservation and recycling appear to be the most energy efficient sources of water if local surface supplies are not available.
- Water supply decisions can significantly affect energy use. These energy implications warrant inclusion in water supply planning and other water management policy decisions.

## A MODEL FOR QUANTIFYING ENERGY IN WATER USE

This chapter introduces a spreadsheet model systematically quantifying the energy use implications of water management decisions in an urban setting. This tool can help policymakers throughout the western United States to better understand the energy implications of their water demand management and water supply decisions. Chapters 4 and 5 apply the model in two agricultural settings: the Westlands Water District in California's Central Valley and Washington's Columbia Basin Project.

The model tracks the energy inputs for the five stages of the water use cycle.[81] This allows planners and policymakers to manipulate these inputs and predict the energy impacts of different water policy choices, such as constructing a desalination facility or implementing a water conservation program. A discussion of the methodological

issues involved in constructing this model is presented in the box below. The full model is presented in Appendix A.

The case studies include enough specific data to reach some policy conclusions. They also help to identify areas where future research would be most worthwhile. Readers are cautioned that the case studies are illustrations of our methods, not full implementations of them. The methods require more location-specific information than could be assembled with the resources available during preparation of this report.

The San Diego case study illustrates how one can evaluate the energy implications of water policy decisions in an urban setting. The data sources, and assumptions used

**METHODOLOGICAL ISSUES**

As in all modeling efforts, there is a boundary question about which energy inputs should be included or excluded from the energy intensity estimates. We include energy used directly in managing water, e.g., pumping, heating, cooling, pressurization, and treatment. The method in this report is not a life-cycle analysis that accounts for indirect energy use such as the energy needed to manufacture and install a water pipeline.

For simplicity, the analysis only lists energy inputs that would change across water policy decisions. For example, the method does not quantify hydroelectric production in the State Water Project or Central Valley Project facilities prior to water intakes in the San Joaquin Delta, and it does not quantify gasoline or diesel fuel used to service these facilities. The policy decisions analyzed in this report would have little impact on these energy uses, so they are excluded.

The method uses water delivered to customers as the denominator of our energy intensity ratios. A qualitative definition of energy intensity is the amount of energy used per unit of water. Because water losses occur in the supply-use-disposal chain, however, there is more than one way to quantitatively define energy intensity. An acre-foot of water diverted by the State Water Project might yield only 0.95 acre-feet of water delivered to a water treatment plant because water evaporates and leaks from aqueducts and canals. If moving that amount of water were to take 100 kWh of energy, one could say that the energy intensity is either 100 kWh/af or 105.3 kWh/af (100/0.95). This same logic applies throughout the supply-use-disposal chain. One must choose water quantities at some point in the chain to use as the denominator in all of the energy intensity calculations in the chain in order to have consistent and meaningful results.

The method treats energy use as linear in the quantity of water transported or used. This is clearly not true at the scale of individual pumps because pumps are more efficient when operating near full capacity. They will use more energy per acre-foot lifted if they are running at half capacity. The linear assumption is often accurate, however, at larger scales because one of several pumps in a bank of pumps can be turned off or on in order to pump less or more water.

Not all energy used to pump or transport water is electric energy. For example, diesel fuel is increasingly used to pump water on farms, and natural gas is typically used to heat water in urban settings. The energy measure in this report is equivalent kilowatt-hours, which is the sum of actual kilowatt-hours and fossil-fuel use converted to kilowatt-hours. The conversion assumes that the fuels were used in thermal power plants to produce electricity.

in the San Diego case study, are listed in Appendix B. The data, however, may not be representative enough of the entire SDCWA service area to support final policy decisions on some issues.

## THE SAN DIEGO CONTEXT

We chose San Diego County for our urban-water-supply case study because it involves a wide range of actual and potential water sources and conservation opportunities. The SDCWA is a regional water wholesaler that has been operating since 1944. It purchases water from the Metropolitan Water District of Southern California to sell to 23 member agencies located within the western third of San Diego County (920,000 acres; 1,437.5 square miles) and serves nearly 3 million residents. The water needs of the member agencies and their retail customers are diverse since the agencies consist of six cities, four water districts, eight municipal water districts, three irrigation districts, a public utility district, and a federal military reservation.

The average annual raw water supply in the SDCWA service area for 1996 through 2000 was approximately 685,000 acre-feet. Average annual raw water supplied by the SDCWA in 2020 is predicted to increase to about 810,000 acre-feet. Because water is lost in conveyance, treatment, and distribution, water currently delivered to customers is around 610,000 af/yr, while projected deliveries in 2020 are about 710,000 af/yr.

### *Key Water Supply Facts*

▶ The Metropolitan Water District obtains water for the SDCWA from the Colorado River Aqueduct (about 470,000 af/yr) and the State Water Project (about 83,000 af/yr) and delivers it to the SDCWA at the boundary of Riverside and San Diego counties.

▶ Water is delivered from the SDCWA to its member agencies through two gravity-fed aqueducts containing five large-diameter pipelines (274 miles total).

▶ Water is delivered from the member agencies to retail customers via approximately 7,800 miles of pipeline.

▶ The local groundwater provides about 30,000 af/yr. One groundwater source is brackish and is treated to potable standards.

▶ Wastewater recycling provides about 18,000 af/yr.

▶ Surface water reservoirs are primarily used as terminal storage for imported water.

▶ The local surface water supply is about 86,000 af/yr.

Water in three of the five principal SDCWA pipelines is treated outside the county at the Metropolitan Water District's Skinner Water Treatment Plant in Riverside County. The SDCWA member agencies also operate 10 raw water treatment plants. Most water delivered by member agencies is treated potable water. The exceptions are recycled wastewater and untreated—raw—water provided for agricultural

purposes. Member agencies operate 14 wastewater treatment plants and 24 water recycling facilities.

The SDCWA has encouraged water conservation and investments in end use efficiency, both directly and through membership in the California Urban Water Conservation Council—the implementing agency for the Memorandum of Understanding for Urban Water Conservation in California. The SDCWA also recognized that energy and water savings can occur together and began a successful partnership with San Diego Gas and Electric, the regional energy supplier, over 10 years ago. Since the collaboration began, more than 550,000 low-flow showerheads have been installed. Over five years ago, SDCWA partnered with San Diego Gas & Electric to offer financial incentives for installing horizontal-axis clothes washers.

## THE SEARCH FOR ADDITIONAL WATER SOURCES

To supplement its current water supplies and plan for the future, the SDCWA has been working for years to arrange a 75-year water transfer agreement with the Imperial Irrigation District, located in southeastern California. The final transfer agreement, signed on October 16, 2003, calls for the SDCWA to receive up to 200,000 af/yr of water. Deliveries will ramp upward during the term of the agreement, providing an average of about 143,000 af/yr over the life of the agreement. The SDCWA will provide the Imperial Irrigation District with up-front payments of $20 million and payments for the transferred water starting at $258 per acre-foot and increasing each year, according to a set price schedule. Additional costs will be incurred to "wheel" this water to San Diego.

In its Regional Water Facilities Master Plan of 2000, the SDCWA identified reducing its dependence on imported water in general and its dependence on water imported from the Colorado River in particular as critical to making its water supplies more stable and reliable. Toward this end, the SDCWA has attempted to diversify and expand its local sources of water, specifically targeting seawater desalination as the preferred alternative.

The SDCWA has considered developing a seawater desalination facility at Encina, which would be constructed adjacent to the Encina Power Station. This project would be the largest seawater desalination plant in the Western Hemisphere, producing 50 million gallons per day (56,000 acre-feet annually) of fresh water. The project is similar to other reverse-osmosis facilities being constructed around the world, including new operating plants in Florida and Trinidad. This new water source would supply up to 8 percent of the region's water needs.

In addition to developing the Encina facility, the SDCWA is evaluating other coastal locations that may be suitable for a regional seawater desalination facility. For example, the SDCWA is currently evaluating the feasibility of a desalination plant adjacent to the South Bay Power Plant in Chula Vista. Other coastal sites being evaluated include the San Onofre Nuclear Generating Station at the north end of San Diego County and sites as far south as the Mexican border.

*The SDCWA also recognized that energy and water savings can occur together and began a successful partnership with San Diego Gas and Electric, the regional energy supplier, over 10 years ago.*

SDCWA is not investigating or supporting any project to import water via ocean-going water bags towed by tug from Northern California or other points north. Nonetheless, the analysis includes an evaluation of water-bag supply to San Diego County as an interesting point of comparison with long-distance transport in canals and pipes. Readers should not construe inclusion of an alternative in this report as an endorsement by the authors or as a comment on the feasibility or appropriateness of any alternative.

## RESULTS OF THE CASE STUDY

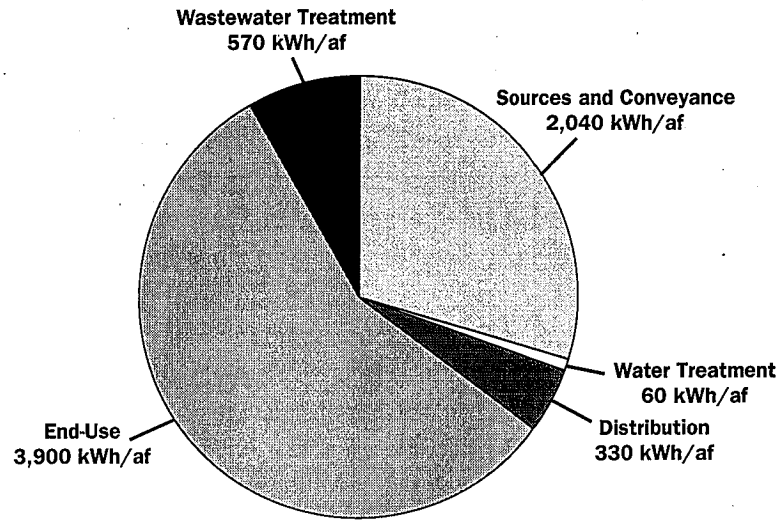
The SDCWA was able to provide some data for all five steps in the water-supply-use-disposal chain. Data from other locations were then used to supplement the analysis when San Diego data were not available. Consequently, the results of the case study analysis should be interpreted cautiously. Remember that the case studies demonstrate the methods and the importance of applying them, but they are based on limited data. Care should be taken in relying on this case study for final decision making until the data sources and assumptions are verified or modified appropriately.

### *End Use Energy Dominates the Water Use Cycle*

Our research revealed that the end use of San Diego's water—heating it for showers, for instance, or pressurizing it for car washes—consumes by far the most energy in the whole water delivery chain. This is a rather striking result given that San Diego County imports most of its water from long distances, requiring large amounts of energy for conveyance.

Figure 4 describes the distribution of estimated total energy use per acre-foot (6,900 kWh) among the five components of the supply-use-disposal chain. Energy use that is integral to end use of water dominates the total.

**FIGURE 4**
**Estimated Energy Intensity Components of Water in San Diego County**



The relatively large amount of energy associated with end use is composed of three types. First, water is sometimes heated for use—for example, for taking showers in homes, for washing dishes in restaurants, or for manufacturing in some industrial facilities. Second, water is sometimes recirculated, pressurized, or lifted in use. Examples include cooling towers, recirculating hot water loops in newer residences, additional pressurization in high-rise buildings, and irrigation pipe pressurization or lifts from canals on farms. Finally, some energy use comes in close conjunction with water use, and may increase or decrease when water is conserved, but is not directly embedded in water. For example, energy is used to run air conditioning compressors that are water-cooled.

The summary number for estimated energy use integral to water end use shown in Figure 4 is presented in more detail in Table 7.[82] The energy intensity estimates are based on the data and assumptions listed in the table notes and are more fully described in Appendix B. Zeros are used when energy use is implausible. "Not Estimated" means data were inadequate to support a credible estimate. The numbers in the table are not significant to the digits shown, but are presented this way to facilitate comparison with other tables and figures.

The estimates in Table 8 probably understate energy use integral to water use because data on water-related energy use in the commercial, industrial, and

**TABLE 7**
**Estimated Energy Use Integral to Water End Use in San Diego County**

| Water Use Category | Estimated Percent of Total Use in 2010 (8) | Estimated Energy Intensity (kWh/af) (8) |
|---|---|---|
| **Residential** | **58%** | |
| Toilets and leaks | 14% | 0 |
| Dishwashers | 1% | 27,200 |
| Clothes washers | 8% | 11,650 |
| Showers, faucets, and bathtubs (1) | 12% | 6,700 |
| Landscape irrigation | 23% | 0 |
| **Commercial, industrial, and institutional** | **32%** | |
| Kitchen dishwashers | 0.5% | 27,200 |
| Prerinse nozzles | 0.2% | 6,700 |
| Other kitchen use | 1.2% | Not Estimated |
| Laundries | 0.6% | 11,650 |
| On-site wastewater treatment (2) | 5.8% | 800 |
| Water-cooled chillers (3) | 2.4% | 67,700 |
| Single pass cooling (3) | 2.4% | 0 |
| Landscape irrigation | 12.1% | 0 |
| Other heated water (4) | 0.3% | 6,700 |
| Other unheated water (5) | 6.5% | Not Estimated |
| **Agricultural (6)** | **10%** | **Not Estimated** |
| **Totals and weighted average (7)** | **100%** | **3,900** |

Notes: (1) Showers and tubs heated to 105 degrees; faucet water conservatively assumed to be cold. (2) Estimate shown is for on-site wastewater treatment. (3) Assumes 50 percent of cooling water is single pass since the SDCWA provides financial incentives for water-efficient cooling investments. (4) CII water heating estimate from Sezgen and Koomey (1995), less other CII water heating estimated separately. (5) May use energy for recirculation or pressurization. (6) Data not available for San Diego County. (7) May differ from figures shown due to rounding. (8) Numbers are not significant to digits shown, but presented this way to facilitate comparison with other tables and figures.

**TABLE 8**
**Energy Intensity of Sources of Water in San Diego County**

| | Energy Intensity (equivalent kWh/af) | Notes |
|---|---|---|
| **Current Source Weighted Average:** | **2,040** | |
| San Francisco Bay Delta (SWP) | 3,240 | Wilkinson (2000) |
| Colorado River (CRA) | 2,000 | Wilkinson (2000) |
| Local surface water | 80 | Raw water lift to treatment plants |
| Local groundwater | 570 | |
| Recycling | 400 | Includes one brackish groundwater treatment facility at 405 kWh/af |
| **Potential Sources:** | | |
| Imperial Irrigation District | 2,110 | CRA (2000) plus hydroelectricity not generated in the All American Canal (110) |
| Seawater desalination | 4,200 | SDCWA seawater desalination facility at Encina |
| Water bags | 1,180 | 900 mile tow |

*Our analysis shows that satisfying all growth in water demand via conservation would reduce the overall energy intensity of the SDCWA water supply by 13 percent.*

institutional (CII) and agricultural sectors are incomplete, and the analysis conservatively omits some uses of energy for which credible estimates could not be made at present (e.g., CII process water heating or recirculation, and water lift or pressurization for agricultural irrigation).

### *Conservation and Water Recycling are the Least Energy Intensive Sources of Potential Supply*

Our analysis shows that satisfying all growth in water demand via conservation would reduce the overall energy intensity of the SDCWA water supply by 13 percent. In comparison, satisfying all growth in water demand via recycling would reduce overall energy intensity by only 4 percent, while using seawater desalination to satisfy growth would increase overall energy intensity by 5 percent.

Table 8 presents the energy intensity of actual and potential sources of water in San Diego County. The first line in the table shows the weighted average energy use for the current mix of water sources.

The results presented above can be taken a step further by assessing the energy intensity implications of various "sources" of additional water (Table 9). An additional 100,000 af/yr implies an additional 108,000 af/yr of water from desalination or recycling facilities because 7 percent of water is estimated to be lost in distribution (i.e., 100,000/0.93 = 108,000). It implies an additional 113,000 af/yr of water delivered to San Diego County via the State Water Project, the Colorado River Aqueduct (presumably Imperial Irrigation District water rerouted to San Diego), or water bags because an estimated 5 percent more is lost in treatment. Or it implies no additional water, but conservation of about 16 percent of the estimated 610,000 af/yr of water actually delivered to customers today after losses in conveyance, treatment, and distribution.

As in the rest of this report, the total energy use is divided by the quantity of water delivered to the end user to calculate the average energy intensity. That

**TABLE 9**
**The Energy Intensity for Satisfying 100,000 af/yr of Additional Demand**

| | Source and Conveyance Energy (kWh/af) | Water Treatment (kWh/af) (1) | Distribution (kWh/af) (2) | End Use (kWh/af) (3) | Wastewater Treatment (kWh/af) (4) | Total (kWh/af) |
|---|---|---|---|---|---|---|
| **Status quo** | 2,040 | 60 | 330 | 3,900 | 570 | 6,900 |
| **Status quo plus scenario:** | | | | | | |
| Conservation | 1,780 | 50 | 290 | 3,400 | 500 | 6,020 |
| Recycling | 1,830 | 50 | 330 | 3,900 | 500 | 6,610 |
| Water bag transfer | 1,950 | 60 | 330 | 3,900 | 570 | 6,810 |
| Imperial Irrigation District transfer | 2,080 | 60 | 330 | 3,900 | 570 | 6,940 |
| Additional State Water Project | 2,240 | 60 | 330 | 3,900 | 570 | 7,100 |
| Seawater desalination | 2,400 | 50 | 330 | 3,900 | 570 | 7,250 |

Notes: (1) The conservation, recycling, and desalination scenarios assume the additional 100,000 acre-feet of water do not require treatment, reducing the average energy intensity of treatment from 60 to 50 kWh/af delivered to customers. (2) Conserved water does not need to be distributed, reducing the energy intensity of distribution from 330 to 290 kWh/af delivered. (3) Conservation assumes no energy is conserved when water is conserved, but no energy is expended to conserve water either. (4) Wastewater is not generated by conservation or by recycling if recycled water is used for landscape irrigation, reducing energy intensity from 570 to 500 kWh/af delivered.

quantity is 710,000 af/yr in all but the conservation scenario. In order to make a fair comparison, however, the conservation scenario also uses a denominator of 710,000 af/yr, although only 610,000 af/yr would actually be delivered to customers. This is an appropriate adjustment because this level of conservation would meet the same need as 710,000 acre-feet would if San Diego were to choose to obtain additional water from the State Water Project or the other sources included in this analysis.

The table shows that water conservation is the far superior water "source" from an energy perspective. Of course, other considerations are relevant to the choice among "source" alternatives. For example, seawater desalination and recycling probably offer greater reliability benefits than the other alternatives.

### *Energy Implications of Water Supply Decisions Are Large and Warrant Inclusion in Water Supply Planning*

Our analysis shows that not only are conservation and recycling the most energy efficient sources of new water supply, but also that shifting to conservation and recycling would generate large energy savings. Total energy savings from relying on conservation instead of additional State Water Project water to provide the next 100,000 acre-feet of water could be approximately 767 million kWh, or enough to provide the annual electricity for 118,000 households—25 percent of all of the households in the city of San Diego.[83] The scale of these potential energy benefits can also be illustrated by another comparison. The amount of energy that this conservation option would save is equal to 150 percent of the maximum annual output of the proposed—but now inactive—62.4 MW Chula Vista II power plant.[84] Relying on recycling rather than additional State Water Project water would save 348 million kWh, or enough to provide for the annual electricity needs of 53,500 households. Total energy use of the alternatives for adding 100,000 acre-feet to the status-quo water supply are presented in Table 10.

This case study demonstrates that water policy choices can save significant amounts of energy. The magnitude of these potential savings has important implications for decision-makers. An integrated approach to assessing San Diego's water supply options could save water and energy, and reduce emissions that contribute to climate change and other air pollution problems. Future planning efforts should capitalize on these opportunities. The type of analysis presented in this case study can easily be incorporated into local and regional water supply planning. Consultation between water agencies, state energy agencies, and local energy utilities can help California better manage our precious water and energy resources.

**TABLE 10**
**Total Energy Use and Savings from San Diego Water Supply Options**

| Status quo plus scenario | Average Energy Intensity (equivalent kWh/af) | Total Energy Required for Water Supply (million kWh/yr) | Savings from Conservation Rather than an Additional 100,000 af/yr of Physical Supply (million kWh/yr) |
|---|---|---|---|
| Conservation | 6,020 | 4,274 | Not Applicable |
| Recycling | 6,610 | 4,963 | 689 |
| Water bag transfer | 6,810 | 4,835 | 561 |
| Imperial Irrigation District transfer | 6,940 | 4,927 | 653 |
| Additional State Water Project | 7,100 | 5,041 | 767 |
| Seawater desalination | 7,250 | 5,148 | 874 |

CHAPTER 4

# WESTLANDS WATER DISTRICT—ENERGY AND AGRICULTURAL WATER



The Westlands Water District is one of the largest agricultural water users in California and the western United States. The district faces long-standing problems associated with soil quality and poor water drainage and is now negotiating with the Department of the Interior to retire—permanently fallow—a large portion of its agricultural lands.[85] In fact, the district has already started the fallowing process by retiring 33,000 acres. Retiring land presents significant implications for California's water use, since it raises the question of where water formerly used for crops will go instead. Our report asks and answers the question: how much energy will be required to use the water in a different way?

This report provides a case study of land retirement in Westlands because the results will be timely and could inform a real policy decision process. The study also illustrates more generally the energy-related issues and data that are necessary for evaluating energy impacts of agricultural water management decisions. Energy impacts have not previously been accounted for in analyses of land-retirement proposals.

This case study evaluates three alternatives for the disposition of the water formerly used to irrigate retired lands in the Westlands Water District: the water could be used to enhance environmental flows in the delta; it could be used on other land within the district; or it could be transferred to other agricultural or urban uses.

As with the San Diego example, care should be taken in making final policy decisions based on this case study without more detailed analysis. In particular, we present some information in the case study that is relevant to land-retirement decisions generally, but is not specific to the land currently proposed for retirement. This information is presented, rather, as an exploration of a new methodology that could be applied in other settings.

Our Westlands analysis indicates that:

- Significant amounts of energy can be embedded in agricultural water use. Agricultural water allocation decisions can have large energy impacts that warrant inclusion in analyses of water policy alternatives.

▶ The total energy implications of agricultural water policy decisions extend far beyond the energy embedded in water. To the extent possible, analyses of energy impacts should include harvest, cultivation, and other energy inputs.

▶ Retiring land south of the Sacramento–San Joaquin Delta and transferring water to environmental flows could save significant amounts of energy—the equivalent of powering more than 18,000 households for one year.

▶ Retiring land south of the delta and transferring water to urban users could dramatically increase energy use. For example, if water were transferred to San Diego County, energy use would increase by more than a factor of 8—that is, by more than 1.2 billion kWh/yr.

▶ Retiring land and allowing water to remain in the district for agricultural use would likely result in an increase in permanent crops, such as orchards, which under plausible assumptions would increase electricity use by 48 percent and total energy use by 16 percent.

*Retiring land south of the Sacramento–San Joaquin Delta and transferring water to environmental flows could save significant amounts of energy—the equivalent of powering more than 18,000 households for one year.*

The model used for the San Diego case study (Appendix A) was modified and simplified for the Westlands case study because many aspects of the urban water cycle (e.g., treatment before use) are usually not present in the agricultural sector. These modifications are described in Appendix C.

## THE WESTLANDS CONTEXT

The Westlands Water District in California is one of the largest agricultural users of water in the West. It has a service contract with the United States Bureau of Reclamation for up to 1,150,000 acre-feet of water per year from the Central Valley Project (CVP). As a junior user in the overcommitted CVP system, Westlands currently receives on average about 65 to 70 percent annually of this amount.

Westlands' total water supply in 2001 was about 1,050,000 acre-feet. Of this total, about 200,000 came from groundwater. A 1980 study by the Bureau of Reclamation, the United States Geological Survey, and Westlands estimated that the sustainable yield of the deep confined aquifer under Westlands is in the range of 100,000 to 135,000 acre-feet. More recent district analysis of monitoring data suggests that the annual average sustainable yield might be as high as 200,000 acre-feet. Table 11 presents the district's

**TABLE 11**
**Westlands Water District Estimates of Water Sources in 2002**

| Source of Water | Estimates for 2002 |
|---|---|
| CVP deliveries | 775,194 acre-feet |
| Groundwater | 200,000 acre-feet |
| Private transfers | 72,000 acre-feet |
| Additional district supplies | 60,000 acre-feet |
| **Total** | **1,107,194 acre-feet** |

estimates of its water sources in 2002. These figures were used in the analysis in this report.

Local groundwater has lower quality than CVP water. Depth to groundwater below the surface varied in 2001 from about 100 feet to 500 feet.[86] Energy consumption per acre-foot of groundwater pumped by the district is about 740 kWh.[87]

Westlands currently includes about 600,000 acres, 95 percent historically irrigable.[88] Approximately 470,000 acres were actually irrigated in 2002. Irrigation water is supplied by the San Luis Unit of the CVP and groundwater wells. Water provided to Westlands by the CVP is diverted from the Sacramento–San Joaquin Delta by the Tracy Pump Station and transferred south via the Delta-Mendota Canal. It is lifted several hundred feet, allowed to flow by gravity for about 150 miles, and is sometimes lifted another several hundred feet into the San Luis Reservoir. Some electricity is generated when water is released from the reservoir, but this offsets only about 70 percent of the energy used to fill the reservoir.[89]

Water is conveyed from the vicinity of the San Luis Reservoir to Westlands via the San Luis and Coalinga Canals. Westlands operates and maintains the 12-mile concrete-lined Coalinga Canal and the Pleasant Valley Pumping Plant, as well as other re-lift stations. Westlands' permanent distribution system consists of closed, buried pipes that convey water from the San Luis Canal, the Coalinga Canal, and a 7.4-mile unlined canal from the Mendota Pool. Approximately 88 percent of the irrigable land in the district is served by the system.

*Water provided to Westlands by the CVP is lifted several hundred feet, allowed to flow by gravity for about 150 miles, and is sometimes lifted another several hundred feet into the San Luis Reservoir.*

Technology for water distribution has become more efficient over the years. In 1996, about 36 percent of irrigated land was watered by gravity distribution alone, about 21 percent by pressurized distribution alone, and the remaining 43 percent by a combination. By comparison, acreage irrigated only by gravity distribution was 63 percent in 1985 and 43 percent in 1990.

## CASE STUDY RESULTS

### *Substantial Energy Is Embedded in Westlands' Water Use*

Sources and conveyance appear to represent the largest portion of energy embedded in Westland's water use. Our analysis indicates that substantial amounts of energy

**TABLE 12**
**Energy Intensity of Surface Water Transport to the Westlands Water District**

| Location of Energy Use | Energy Intensity (kWh/af) |
|---|---|
| Tracy Pump Station (1) | 238 |
| Lift from O'Neal Forebay (1) | 59 |
| Lift to San Luis Reservoir | 300 |
| Hydroelectric generation from releases from the San Luis Reservoir (2) | –210 |
| Dos Amigos Pump Station | 138 |
| **Total CVP to the San Luis Canal** | **435–525** |
| Pleasant Valley Pump Station | 238 |
| **Total CVP to the Coalinga Canal** | **673–763** |

Notes: (1) The State Water Project Banks Pump Station is a parallel path for water en route to the San Luis Reservoir and eventually Westlands. Its energy use is nearly identical to the CVP pumps. (2) A negative number represents energy recovery, not use.

**TABLE 13**
**Electrical Energy Requirements to Lift or Pressurize Sprinkler Systems**

| Activity | Approximate kWh/af |
|---|---|
| Flood irrigation without on-farm lift | 0 |
| Lifting water 10 feet for flood irrigation | 30 |
| Low-pressure sprinklers | 100 |
| Permanent set sprinklers | 205 |

are required to deliver water to Westlands' fields, whether surface or groundwater. Energy required for water pumping in the CVP is presented in Table 12.[90] Totals in the table are approximate and lower than actual consumption per acre-foot because water losses between pumping locations are not accounted for. Ranges represent uncertainty about whether water to Westlands should be charged 90 kWh/af for lift into or release from the San Luis.[91]

*Our analysis indicates that substantial amounts of energy are required to deliver water to Westlands' fields, whether surface or groundwater.*

The amount of energy required to deliver water to a field in Westlands can vary widely depending on the location of that field within the district. Net electric energy consumption by the CVP to deliver water to canals in the Westlands Water District varies from about 435 to 763 kWh/af.[92] In addition, staff members report that district lift from the canals consumes about 245 kWh/af.[93] This implies that water available to farmers at the boundaries of their properties requires between 435 and 1,008 kWh/af.

Once water has been delivered to the field, additional energy may be required to lift and pressurize that water. Table 13 summarizes some average on-farm energy requirements for these irrigation purposes. It assumes a 10-foot lift and pressurization for the sprinklers. The figures are estimated from unit prices for electricity and expenditures per acre for water pumping and pressurization provided by the California Energy Commission in 2001 for grapes and almonds. The figures in the table are not specific to Westlands. The energy required for permanent set sprinklers is 20 to 47 percent of the energy required to deliver water to farms within Westlands (435 to 1,008 kWh/af). This demonstrates that energy used in on-farm water delivery systems can be significant in agricultural settings, depending on the types of crops grown and the choice of irrigation system.

Hydroelectric power issues are relatively insignificant for the Westlands analysis. Hydroelectric power production from the CVP is substantial (more than 4.5 billion kWh/yr), but nearly all irrigation water supply—such as that to Westlands—occurs downstream of CVP hydroelectric facilities. Therefore, there is no direct trade-off between irrigation and power generation as there is in the Columbia Basin study that follows. In addition, none of the scenarios analyzed in this case study would result in a dramatic change to hydroelectric operations upstream of the delta.

***Energy Implications of Land Retirement Extend Beyond Water Delivery and Use***

As discussed in Chapter 2, the full energy implications of a water policy decision may extend beyond the energy embedded in the water. In this case, permanent land

**TABLE 14**
**Energy Intensity of Liquid Fuels Used to Cultivate and Harvest Crops**

| Crop | Energy Intensity (kWh equivalent per acre) |
|---|---|
| Alfalfa—California | 145 |
| Alfalfa—Ohio | 205 |
| Almonds | 341 |
| Almonds | 373 |
| Cotton—Alcala | 472 |
| Cotton—Pima | 545 |
| Tomatoes, processing | 1,255 |
| Tomatoes, fresh | 710 |
| Tomatoes, "typical" California | 1,389 |
| Wheat | 247 |

Notes: Gasoline and diesel fuel converted to BTUs at 150,000 per gallon; BTUs converted to equivalent kWh at 10,239 per equivalent kWh.[94]

retirement would affect energy use in ways that are not captured by looking only at energy embedded in irrigation. In addition to irrigation, farms consume energy by operating farm machinery preparing soil, applying fertilizers and pesticides, and harvesting crops.

*Permanent land retirement would affect energy use in ways that are not captured by looking only at energy embedded in irrigation.*

This nonirrigation energy use varies enormously across crops.[95] Table 14 presents some sample calculations of gasoline and diesel energy used in agriculture. Again, these are not specific to Westlands but illustrate the type of analysis that is required to understand the energy implications of agricultural water use decisions. Energy used for irrigation is not included in the gasoline and diesel-fuel energy consumption estimates unless a power takeoff from farm machinery is used to drive a water pump.

To determine the nonirrigation energy savings from a land-retirement program, it is necessary to determine which crops will be phased out. Table 15 presents projected 2020 cropping patterns for Westlands without significant land retirement.[96] Crops projected for lands with shallow groundwater represent drainage-impaired lands that are candidates for retirement. The projection is extremely uncertain because it is based on estimated future market prices for crops obtained by extrapolation from historical trends and expert opinion. These trends and opinions may be altered by changes in other parts of the western United States and international agricultural regions that have not been evaluated. Nonetheless, Table 15 is the best available data on the types of crops that might not be grown in drainage-affected areas if significant retirement programs are implemented.

Cotton takes up more than a third of the acreage likely to be grown on land with shallow groundwater. Cotton also represents a midpoint in its nonirrigation energy use listed in Table 16, roughly 500 equivalent kWh/acre. Therefore, a rough estimate of the nonirrigation energy savings associated with retiring 100,000 acres of land is approximately 50 million equivalent kWh. Note that these are nonelectric savings that have been converted to kWh. Although these potential savings are not available to other customers as electricity, they are important additional implications of land

**TABLE 15**
**Forecast Demand for Westlands Crops in 2020**

| Crop | Shallow Groundwater (thousands of acres) | Remainder (thousands of acres) |
|---|---|---|
| Alfalfa hay | 8.04 | 0.96 |
| Cotton | 73.72 | 83.76 |
| Field crops | 5.57 | 14.80 |
| Irrigated grain | 9.19 | 1.72 |
| Grapes | 1.40 | 8.02 |
| Irrigated pasture | 0.23 | 0.8 |
| Orchards | 2.75 | 55.03 |
| Row crops | 31.22 | 109.83 |
| Sugar beets | 0.98 | 0.96 |
| Subtropicals | 3.55 | 1.03 |
| Tomatoes | 17.45 | 97.56 |
| Dry-land grain | 14.00 | 0.00 |
| Fallow and nonbearing trees and vines | 22.39 | 11.99 |
| **Total: (577,000 acres)** | **190.49** | **386.46** |

*Our analysis indicates that dedicating water from retired lands to environmental flows in the delta would have the greatest energy benefits.*

retirement because of the potential for air quality and global warming benefits that are beyond the scope of this analysis.

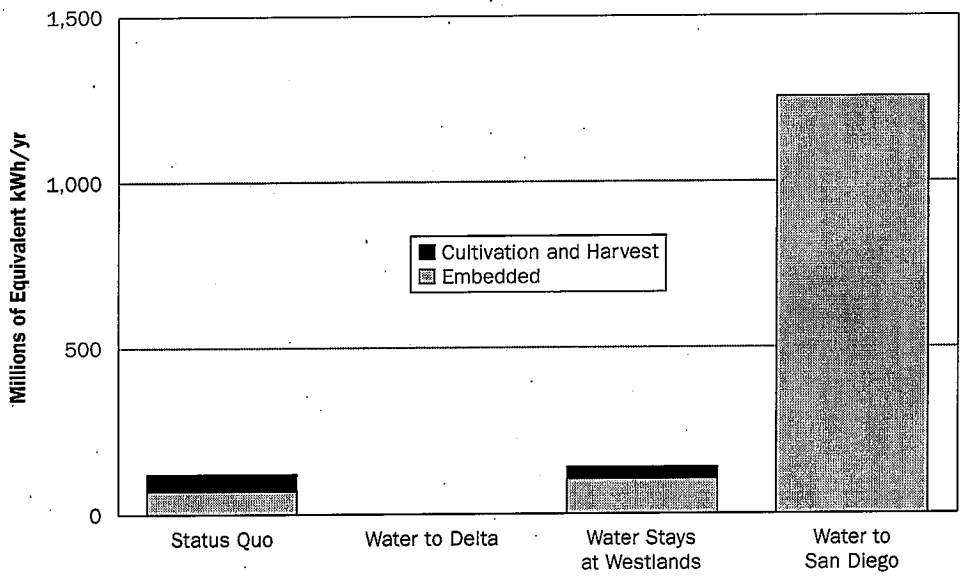
***Dedicating Water to Environmental Flows Could Save Significant Energy***

Long-standing problems associated with inadequate drainage, low quality of existing drainage water, and responsibility for management and disposal of drainage flows have led to recent proposals to retire—permanently fallow—200,000 acres within the district.[97] Under a Westlands proposal, farmers would receive federal payment for a significant part of the cost of land retirement, and the Westlands Water District would obtain or keep title to the land and all water associated with the land.

In concept, there is broad support for the retirement of drainage-impaired land on the west side of the San Joaquin Valley. However, current proposals are controversial for a variety of reasons not discussed in this report, including disposition of conserved water and the claim that the public cost of the retirement is higher than the public benefits that will be obtained. This case study considers three alternatives for the disposition of the water formerly used to irrigate the retired lands: dedicating the water to enhance environmental flows, transferring the water to other water users, and retaining the water for irrigation on other Westlands land. Summary statistics for the three alternatives are presented in Figure 5.

Our analysis indicates that dedicating water from retired lands to environmental flows in the delta would have the greatest energy benefits. The land targeted for retirement is predominantly downslope of the San Luis Canal and therefore receives water by gravity. On-farm pressurization is reported by Westlands staff to be minimal for these lands. Consequently, a conservative estimate of energy saved by reducing CVP water deliveries to Westlands, with that water left in the

**FIGURE 5**
**Annual Energy Use by Water Disposition Scenario**




San Francisco Bay-Delta for environmental purposes, is approximately 435 kWh/af. While average applied water in the district is 2.34 af/acre (1.1 million acre-feet divided by 470,000 cropped acres in 2002), not all of this is CVP water that could be dedicated to environmental flows. Since CVP water represented 70 percent of the district's 2002 supplies, we assume that 70 percent of the average applied water is CVP supply. Therefore, a 100,000-acre land-retirement program could save approximately 71 million kWh of electricity, or enough to power 11,000 households for a year.[98]

The full energy implications of land retirement extend beyond the energy embedded in water. Retiring 100,000 acres in Westlands and dedicating the conserved CVP water to environmental flows in the delta could have total energy implications of 121 million equivalent kWh (71 million kWh of embedded energy plus 50 million equivalent kWh used for cultivation and harvest).

It is important to note, however, that reduced groundwater pumping within the district would save even more electricity. Pumping groundwater alone uses about 740 kWh/af.[99] Electricity savings would be around 120 million kWh/yr if CVP deliveries were maintained and the district decreased groundwater pumping in the equivalent amount. Any pattern of reduction in total water use in the district implies significantly less electric and total energy use. However, given the lack of groundwater regulation in California at the moment, a retirement agreement would need to include special legal and enforcement provisions in order to ensure any reduction in groundwater pumping.

This analysis has implications for the Environmental Water Account, included in the CALFED Bay-Delta Program Record of Decision, signed in August 2000. The Environmental Water Account was created to provide water to compensate water

users for delta pumping reductions needed to protect endangered species, and, if enough water remains, to restore the bay-delta ecosystem. From an operational perspective, this complex arrangement can be identical to dedicating existing water consumed by irrigation to delta protection. The Environmental Water Account water can come from a number of sources, including the purchase of surface and groundwater and purchases north or south of the delta. The extraction of groundwater for the Environmental Water Account requires greater energy than purchases from existing gravity-fed surface water facilities. Water purchases from agriculture north of the delta would result in changes in agricultural operations with relatively small conveyance energy benefits. The Environmental Water Account water purchased from CVP contractors south of the delta, such as Westlands, would generate greater conveyance energy benefits than water purchased north of the delta. The greatest conveyance energy benefits from Environmental Water Account purchases in the Central Valley would be achieved from purchases of surface water from the Central Valley location with the greatest lift for imported delta irrigation supplies—Kern County.

***Transferring the Water to Urban Users Would Dramatically Increase Energy Use***

Transferring water from Westlands to urban locations would significantly increase energy use. Table 16 presents the conveyance energy that would be required to transfer the water to urban users.[100] As documented in the San Diego case study, other parts of the water cycle—water treatment, distribution, end use, and wastewater treatment—also use energy. Figure 5 uses data from the San Diego case study and Table 16 to estimate the energy use that would result if water conserved by retiring 100,000 acres in Westlands were transferred to San Diego. Total energy use—all electricity in this scenario—would increase by more than eight times the energy use in the status quo: more than 1.2 billion kWh/yr.

Water from land retirement at Westlands could also be transferred to other agricultural users. Transfers to locations that use less energy for conveyance (e.g., north of Westlands, such as the Sacramento Valley area) would have net energy benefits unless the types of crops and irrigation systems at the new location were sufficiently more energy intensive than those on retired lands at Westlands. In contrast, transfers to locations that use more energy for conveyance (e.g., south of Westlands, such as Kern County) would have net energy costs unless the types of

**TABLE 16**
**Energy Used to Deliver Water to Various Users**

| Representative Points of Delivery | Energy Intensity (kWh/af) |
|---|---|
| Environmental flows in the Sacramento–San Joaquin Delta | 0 |
| Westlands Water District | 435–1008 |
| San Jose area | 1,165 |
| Santa Barbara area | 2,826 |
| Northern Los Angeles Basin | 2,580 |
| Southern Los Angeles Basin | 3,236 |

crops and irrigation systems at the new location were sufficiently less energy intensive than those on retired lands in the district.

### *Retaining Water at Westlands Could Increase Energy Use*

Westlands proposes to keep water formerly used to irrigate retired lands and reallocate this water to remaining agricultural lands within the district. Determining the energy implications of this policy requires forecasting the impact of water supply changes on cropping patterns. For example, land retirement without reduction in CVP deliveries creates greater reliability and availability of water per acre of land still farmed. One recent study estimates that a 39 percent increase in permanent crops, such as orchards, would result from increased reliability of water supply.[101] These reliability benefits are one reason Westlands has been pursuing its own land-retirement program.

District staff report that this level of increased tree planting would consume about an additional 170,000 af/yr.[102] Assuming for illustration purposes that permanent set sprinklers are used to deliver this amount of water previously delivered by gravity to retired lands, electricity use would increase by about 200 kWh/af. This would amount to about 35 million kWh/yr, as shown in Figure 5. In addition, irrigating orchard lands might require an additional 245 kWh/af for district lift from the canals, increasing electricity use even more than is presented in Figure 5.

The impact on other energy use on farms, however, might be positive. Tree crops tend to use less energy for cultivation and harvest than row crops. Figure 5 shows a reduction in energy used in cultivation and harvest that reflects 150 equivalent kWh per acre saved by switching from cotton to almonds. This type of change might amount to 15 million equivalent kWh/yr less energy use.

Overall, allowing Westlands to continue using water now applied to the retired lands would increase total energy use by approximately 19 million equivalent kWh/yr under the assumptions used. These assumptions illustrate the type of analysis that is important to perform when evaluating land-retirement proposals, such as the one for Westlands, but are only approximately accurate and should not be relied upon in making final decisions about land retirement in Westlands.

The analysis in this case study demonstrates three points that are relevant to agricultural water management decisions and worthy of further research:

- The importance of accounting for end use energy in agriculture;
- The importance of understanding the changes in land use or cropping patterns that are likely to result from a land-retirement decision;
- The importance of clearly defining, in an enforceable manner, the ultimate disposition of water no longer required to irrigate land that is retired.

Unfortunately, these concerns could not be quantified in further detail within the resources available for this report. But our analysis demonstrates that these concerns are quantitatively significant relative to energy use in agricultural water conveyance and distribution—a point that had not been established prior to this report.

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ENERGY DOWN THE DRAIN

*The Hidden Costs of California's Water Supply*

August 2004

CHAPTER 5

# THE COLUMBIA RIVER BASIN—ENERGY AND HYDROPOWER

The Columbia River supports powerful farming, hydropower, and environmental interests, and their competing concerns reveal just how complex the relationship between energy and water can be.

Thanks to its unique plumbing, the Columbia River has numerous hydroelectric dams located downstream of major irrigation diversions. As a result, energy and water policy discussions have been more integrated here than elsewhere in the West. Despite this initial progress, however, water and energy planners in the region have a long way to go toward fully integrating energy and water policy. This shortcoming was brought into sharp focus by the drought and energy crisis of 2001, when energy production demands caused farmers, industry, and the environment to suffer severely.

In this chapter, we examine the energy implications of diverting irrigation water upstream of hydroelectric facilities. Our analysis leads to several key findings:

- A substantial amount of energy is embedded in the water consumed by agricultural users where substantial pumping is required to deliver water.

- When accounting for the energy costs of irrigation along rivers that have hydroelectric dams downstream of major irrigation diversions, policymakers must examine both the energy used to deliver the water to the field and the energy foregone, or not produced, as a result of taking water out of the river before a dam.

- In future droughts, cost-effective water transfers may make it possible to improve conditions for salmon, power generation, and agriculture.

The model used in the Westlands Water District chapter was abbreviated for this case study to focus on the diversion of water for agricultural purposes upstream of hydroelectric facilities. Nonetheless, the Columbia analysis shares the methodology used in the other case studies, and is described in Appendices A and C.

While the Westlands and San Diego case studies focused on the energy embedded in agricultural and urban water use, this case study takes the analysis a step further by examining another important energy implication of water use: energy production that is lost or foregone as a result of water policy decisions. This

opportunity cost must be included in any calculation of how much energy is embedded in water use.

This case study also includes a discussion of the energy required to plant, cultivate, and harvest crops—additional energy use associated with water used by agriculture. By more fully analyzing the energy implications of water used in agriculture, this methodology allows for the more accurate calculation of the potential energy savings of dry-year fallowing agreements. Water marketing arrangements are increasingly common throughout the West. This methodology allows us to demonstrate the potential energy benefits of some of these transfers.

## THE COLUMBIA RIVER CONTEXT

The Columbia River travels over 1,200 miles from its headwaters to the Pacific Ocean, draining a watershed of 259,000 square miles and discharging an annual average of 160 million acre-feet (Figure 6). The Columbia and Snake Rivers are, respectively, the

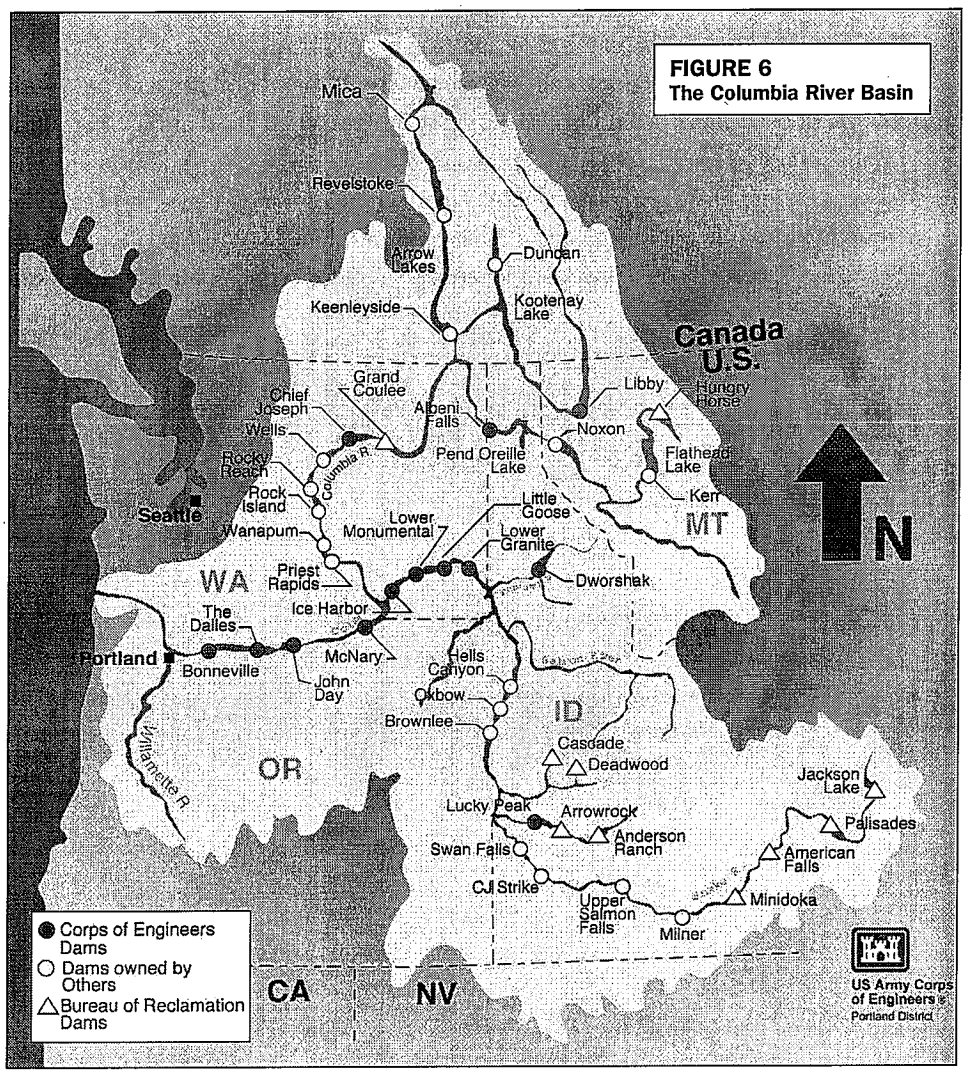



**FIGURE 6**
**The Columbia River Basin**

12th and 13th longest rivers in the nation. This river system is an international and interstate resource that provides the basis for the region's charm, history, environment, recreational opportunities, and agricultural and industrial successes.

### *The Decline of the Columbia River Ecosystem*

Human activities have taken a heavy toll on the Columbia River and its fisheries. The Columbia once supported more than 11 million salmon and steelhead annually, but by the 1990s, the river supported only about one million anadromous fish.[103] This remaining population consists of a majority of unsustainable hatchery fish and a very small population of wild spawning fish. Table 17 presents the 12 evolutionarily significant units of anadromous fish now listed under the Endangered Species Act as endangered or threatened in the basin. A variety of causes are responsible for this decline; however, diversions and dams have played a primary role.

Unfortunately, an effective response to restore Columbia fisheries has not yet emerged. Fishery management is particularly complicated due to perceived conflicts among energy, irrigation, and the environment.

### *Hydropower on the Columbia River*

Dams in the Columbia River system represent 95 percent of the region's hydroelectric supply and produce 60 percent of its electricity.[104] The 31 dams owned by the Bureau of Reclamation and the Army Corps of Engineers make up the Federal Columbia River Power System (FCRPS). In 2000, the National Marine Fisheries Service issued a Biological Opinion (BiOp) regarding the impacts of the FCRPS on anadromous fish. The BiOp recommended 199 actions to enable listed fish populations to survive rather than continue to decline.[105]

The actions regarding hydropower call for augmenting flows and spilling water through spillways or bypasses. The 2000 BiOp also recommends specific quantities of water for flow augmentation and spill at the federal hydroelectric dams. If insufficient progress is made toward restoring fisheries, stronger measures, such as breaching four Lower Snake River dams, may need to be pursued.

**TABLE 17**
**ESA Listed Fish of the Columbia Basin**

| | Endangered | Threatened |
|---|---|---|
| **Resident Fish** | Kootenai River white sturgeon | Bull Trout |
| **Anadromous Fish** | Snake River sockeye<br>Upper Columbia River spring Chinook<br>Upper Columbia River steelhead | Snake River spring/summer Chinook<br>Snake River fall Chinook<br>Snake River steelhead<br>Middle Columbia River steelhead<br>Lower Columbia River Chinook<br>Lower Columbia River steelhead<br>Columbia River chum salmon<br>Upper Willamette River Chinook<br>Upper Willamette River steelhead |

Source: U.S. Bureau of Reclamation, Finding and Commitments. Implementing December 2000 Biological Opinions for the Federal Columbia River Basin System and Other Related Actions, 2001.

### Agriculture in the Columbia Basin

The diversion of millions of acre-feet of water from the Columbia Basin has enabled farmers to grow crops in the arid climate of the interior Northwest. While the economy has diversified in the last 20 years, agriculture remains a major industry. Major crops in the Columbia Basin include potatoes, alfalfa, sugar beets, wheat, and onions. The potential crops in much of this region are limited by the relatively short growing season for high-altitude farmland.

About 6 percent of the Columbia's flows are diverted for agricultural purposes.[106] While this seems like a low number, the National Marine Fisheries Service says that "Water withdrawals for irrigation throughout the Columbia River Basin have an enormous effect on the flow of the Snake and Columbia rivers, especially during dry years when river volumes are low."[107]

## THE DROUGHT OF 2001

The drought of 2001 in the Pacific Northwest was one of the worst on record, comparable to the drought of 1977. By the summer of 2001, instream flows were naturally low and were further exacerbated by water diversions. The pumps for some of these diversions consumed significant amounts of energy. Low rainfall affected farms and reduced hydropower generation. Spot market power was prohibitively expensive because of the California electricity crisis. Salmon advocates, irrigators, and generators feared the worst. Decisions made during 2001 imposed major hardships on the environment, particularly salmon. With naturally producing salmon populations already at disastrously low levels, management of the Columbia River pushed many species closer to extinction.

*Other load-reduction programs simply purchased the hydropower used to pump irrigation water, leading farmers to substitute diesel generation to run their pumps.*

### Hydropower Impacts from the Drought

Understandably, Northwest utilities were concerned about avoiding blackouts during the summer of 2001. Bonneville Power Administration (BPA) responded by declaring an emergency situation, thereby avoiding carrying out some of the BiOp actions designed to help salmon recover, including much of the scheduled spill over the dams for fish passage. Utilities also launched several energy load-reduction programs and encouraged conservation.

The two largest agriculture load-reduction programs were run by the Idaho Power Company in Idaho and the BPA in the Columbia Basin Project. Some programs paid farmers not to pump irrigation water, freeing up for other uses the energy typically used for pumping and leaving water in the river for downstream generation. Most of this water was sent through the generating plants rather than spilled. Other non-BPA load-reduction programs simply purchased the hydropower used to pump irrigation water, leading farmers to substitute diesel generation to run their pumps, worsening air pollution and generating no in-river benefits.

The drought response included industrial load-reduction programs as well. One major focus of this effort was the energy intensive aluminum smelting industry. Creative BPA load-reduction programs cut power use during 2001 while ensuring continued compensation for plant workers.[108] The load-reduction programs during

2001 allowed the BPA to continue exporting significant amounts of power to assist California during its power crisis. This demand for energy exports increased the challenges facing those managing the Columbia River system.

Although the drought required major efforts in the energy arena, the overall response to the drought was considered a success for the utilities. No blackouts made the headlines during the drought of 2001 in the Northwest.

### *Agriculture Impacts of the Drought*

In the agricultural community, there was little that could be termed a success. Higher energy prices increased costs. The drought caused yields to fall. Low commodity prices worsened conditions. Because of overproduction, farmers were earning only $1.50 per 100 pounds of potatoes, although it takes $4 to $5 to grow a hundred pounds, leading the United States Farm Services Agency to institute a program to buy potatoes and raise prices.[109]

The irrigation buyback programs offered by utilities provided a lifeline for some of the unfortunate farmers facing low commodity prices and high energy cost. However, despite the financial appeal of the buyback programs, for a variety of reasons, it remained far more difficult to obtain water in the Upper Snake River than in other regions. By way of contrast, the Washington State Department of Ecology spent more than $300,000 to secure in-stream flows from farmers through 21 leases during this same drought.[110]

During 2001, buyback programs helped some farmers to survive during difficult farming conditions. According to one media report, "Some Idaho farmers reported that kilowatt hours were their best crop [in 2001]."[111] Implementing the recommendations discussed in Chapter 6 would allow farmers to use their water rights to provide a cushion against the challenging conditions facing them in the agricultural market.

### *Environmental Impacts of the Drought*

For Columbia Basin fish, things were even bleaker. Already struggling to migrate past numerous dams, anadromous fish faced even lower flows because of the drought. In the Hanford Reach, 1.6 million young Chinook were stranded. In 2001, the drought prevented the agencies from meeting any of the BiOp objectives. Relying on the drought emergency, federal agencies reduced spills over the summer to only 10 percent of BiOp recommendations. The Fish Passage Center and the National Marine Fisheries Service both found that "the lowest survivals and slowest travel times for smolts resulted from the lowest flow and spill that has occurred in recent years."[112] In harsher terms, Save Our Wild Salmon characterized the hydropower operations as a "massacre."[113]

According to the Fish Passage Center, "the suspension of Biological Opinion measures resulted in very poor in-river migration conditions in 2001."[114] For endangered fisheries, 2001 represented another disturbing step toward extinction rather than recovery.

### *Lessons from the 2001 Drought*

Was there any way to meet expected electricity needs without sacrificing the salmon? Some groups believed so. In a letter addressed to Congress on March 19, 2001,

environmental groups, scientists, and Native American tribes proposed that water be obtained from a point higher in the Columbia Basin, so that instream flows could be maintained while hydropower generators met their needs.

Clearly, hydropower generation was given the highest priority for Columbia water resources in 2001. Agricultural, industrial, and fishery interests all suffered, but there were no blackouts in the Northwest that year. Many farmers and industrial interests were compensated for reduced power—and water—use. Fish and fishery interests, including fishermen and Native Americans, however, had no choice and bore major hardships. In short, during 2001, several key factors came together:

- The drought worsened conditions for hydropower production.
- Exacerbated by diversions and power operations, the drought threatened the environment, particularly salmon.
- Spills over hydroelectric dams were inadequate.
- River flows were inadequate.
- Power prices peaked, due to the electricity crisis in California.
- Commodity prices were low.

These factors and the priorities given to the various uses of water in the Columbia River system led to a particularly unfortunate outcome—Idaho farmers lost money and plowed under unwanted, but water intensive, potatoes, while fish and hydropower production suffered from a lack of water. It is important for us to learn from this experience. It may be possible to address all of these problems during dry years by capturing some of the energy opportunity cost embedded in irrigation water in this region.

*Idaho farmers lost money and plowed under unwanted, but water intensive, potatoes, while fish and hydropower production suffered from a lack of water.*

## CASE STUDY RESULTS

The Columbia case study examines energy implications of water use in one large federal project, the Columbia Basin Project (CBP). This project is located near Grand Coulee Dam, upstream of many of the Federal Columbia River Power System hydroelectric generating facilities. To simplify this effort, this analysis focused on the implications of only one crop, potatoes. Potatoes are one of the major crops in the Columbia Basin. Just as salmon are an iconic wildlife species for the Pacific Northwest, potatoes are agriculture's signature crop in parts of the region.

### *Significant Amounts of Energy Are Embedded in Agricultural Water Use*

In the Columbia Basin Project, delivering water requires a significant amount of energy: 340 kWh per acre-foot. Our analysis of embedded energy use is shown as source and conveyance energy in Figure 7. This figure also shows the energy required to plant, cultivate and harvest this crop—385 kWh per acre-foot. Cultivation and harvest energy use, however, comes primarily in the form of diesel fuel consumption. Saving this energy is not, therefore, translatable directly into electricity. Nevertheless, it is also an important energy implication of water use by agriculture.

**TABLE 18**
**Downstream Generation Gain from Reduced Diversion**

| Site | Net Energy Gain (kWh/af) |
|---|---|
| Columbia Basin Project | 745 |
| Upper Salmon | 250 |
| Walla Walla | 140 |
| Deschutes | 36 |
| Upper Snake | 806 |

### *Energy Generation Opportunity Costs Must Be Added to Embedded Energy Costs*

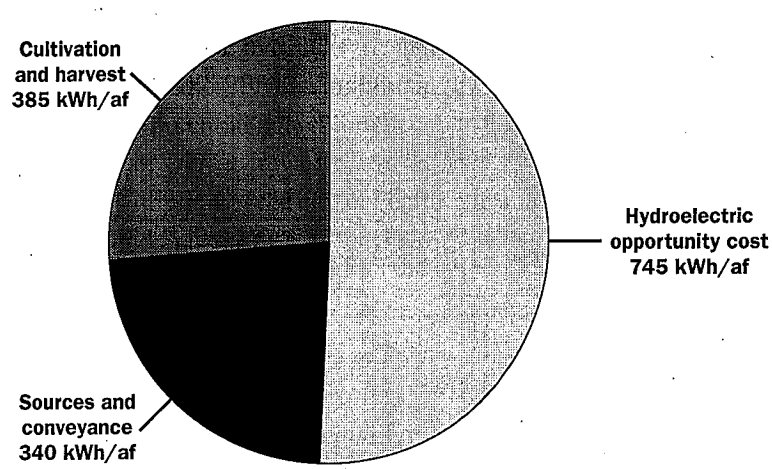
Because diversions from the CBP are upstream of major hydroelectric generation facilities, these diversions reduce the amount of water passing through those downstream facilities. Thus, one result of CBP diversions is a significant reduction in potential energy production. Figure 7 shows that this opportunity cost is 745 kWh/af. This hydroelectric opportunity cost was taken from Table 18, which summarizes the per-acre-foot energy potential of water at five points in the river system. Predictably, the energy opportunity costs in upper watersheds, above major hydroelectric dams, are extremely significant. In the case of the CBP, the energy opportunity cost is actually greater than the energy used to deliver water and to cultivate and harvest crops (725 kWh/af combined). Clearly, in regions like the Columbia River Basin, a full understanding of the energy implications of water use must include energy opportunity costs.

The total electricity implications of water used by the Columbia Basin Project can be estimated by multiplying the total electricity embedded in each acre-foot of water (to pump water from the Columbia River to the users) and potential downstream generation benefits from water released below the CBP (1,085 kWh/af—including both conveyance and downstream hydroelectric generation) times the annual average amount of water diverted by the CBP (2.4 million af/yr).[115] This exercise reveals that the embedded energy and potential generation benefits of the Columbia Basin Project alone amount to more than 2,600 gigawatt-hours per year, or nearly 25 percent of total annual energy consumption of the city of Seattle. An analysis of other diversions in the upper Columbia and Snake River systems would reveal similarly significant energy implications.

### *Water Transfers Could Benefit All Parties in Future Droughts*

By combining embedded energy and opportunity costs, Figure 7 reveals the potential energy benefits of dry-year water transfers involving the Columbia Basin Project in

**FIGURE 7**
**Energy Intensity of Water of Potatoes from Reduced Diversions**



the future. Of the 1,470 equivalent kWh/af total energy implications of CBP water use, 1,085 consist of electricity used to pump water plus electricity not produced because water was diverted upstream of hydroelectric facilities.

This analysis demonstrates that if all water diversions to the Columbia Basin Project were to cease and if all of this water were instead run through downstream hydroelectric facilities, the additional energy produced would be more than 2,600 gigawatt-hours per year. We do not mean to suggest that this would be an appropriate reallocation. However, this analysis reveals the significant potential energy benefits that could accrue from realizing some of this potential under some circumstances. The BPA has conducted an analysis looking at different hydrological conditions that has reinforced this conclusion.[116]

During dry years, and especially when power costs are high and agricultural commodity prices are low, the value of this energy potential may be large enough for voluntary fallowing programs to pay farmers more than they could earn growing low-value crops and still have enough money left to purchase environmental flows. Such an arrangement would pay farmers to forego farming on some of their land, leaving more water in the river. Some of the conserved water could be used to generate additional energy, and some used to generate environmental benefits. Such hybrid energy and environmental transfers could improve low-flow conditions in places such as in the Hanford Reach, which suffered the large fish kill discussed previously. They could also help provide the spills from hydroelectric facilities required by the 2000 BiOp. During the disastrous conditions seen in 2001, voluntary fallowing arrangements could also have been beneficial to many farmers who lost money as a result of high production and low crop prices. In short, the opportunity for farmers, ratepayers, and the environment to mutually benefit from dry-year land fallowing in the Columbia Basin is significant.

*The embedded energy and potential generation benefits of the Columbia Basin Project alone amount to nearly 25 percent of total annual energy consumption of the city of Seattle.*

Experience in other states suggests that the greatest concerns regarding the type of marketing arrangements that this document recommends are likely to emerge from rural agricultural communities. We take these concerns seriously and will explore them further in a forthcoming report.

## CONCLUSION

There are a few things upon which everyone associated with the management of the Columbia River would agree. The region will face droughts in the future. In fact, by reducing snowpacks, global warming may increase the frequency and severity of drought conditions in the future. These droughts will reduce the reliability of energy supplies that are essential to the region's economic vitality. Salmon populations are already at dangerously low levels and could be seriously imperiled in future droughts. And farmers in much of the basin are struggling to survive due to low crop prices and high costs. Any strategy that offers the potential to provide benefits in each of these interconnected areas deserves thoughtful evaluation. Voluntary dry-year marketing arrangements offer the potential to improve conditions for salmon, increase energy production, and provide badly needed income for farmers. The

*Some of the conserved water could be used to generate additional energy, and some used to generate environmental benefits.*

potential impacts of such arrangements on local communities should be carefully evaluated. However, if designed properly, such arrangements could significantly strengthen the region's economy and protect many thousands of jobs from potentially disruptive energy shortages.

On the Columbia River and on other river systems, a better understanding of the energy implications of water use can help managers design strategies in the future that will better meet the needs of our economy and environment. In these cases, the careful, regulated use of market principles offers the potential to produce broad benefits reflecting modern environmental values.

CHAPTER 6

# RECOMMENDATIONS FOR WATER POLICY



The case studies in this report support water policy conclusions that are widely applicable in the western United States. Overall, our analysis indicates that energy implications of water policy decisions are large and warrant inclusion in water and energy policy decisions. All three case studies demonstrate that inclusion of energy considerations can improve resource management decisions and avoid potentially significant unintended energy consequences.

## ENERGY IN URBAN WATER USE

The most striking conclusion is that the amount of energy required for end uses of water is the largest component of energy use in the urban water supply cycle. Therefore, urban conservation, particularly for energy intensive uses such as clothes washers and commercial cooling towers, is important regardless of the source of the water or location of its use. San Francisco, as well as Los Angeles, should be aggressively pursuing water conservation.

This finding implies that policy actions that affect water use may have much larger energy implications than policy actions that affect the mix of physical water sources. This is true in San Diego, at the most energy intensive "ends" of the State Water Project and Colorado River Aqueduct, but it is even more valid in other locales.

However, our analysis also reiterates that conveying water can be highly energy intensive. Since conservation saves all of the "upstream" energy inputs as well as end use inputs, conservation in areas with energy intensive water supplies will save substantially more energy than conservation in other areas.

Another conclusion from the urban case study—as well as the agricultural analysis—is that water reuse is far less energy intensive than any physical source of water other than local surface water. The San Diego case study explicitly supports this point, and tailwater recovery uses far less energy than urban water recycling since it usually requires no more than lifting tailwater from low points to high points on each farm. Even groundwater pumping is more energy intensive in San Diego and the Westlands Water District than water recycling from urban wastewater; and the depth to groundwater in these locations is not atypical for western settings.

## ENERGY IN AGRICULTURAL WATER USE

In agricultural settings, energy use varies widely and it is not possible to generalize about which stage of water use dominates. Source and conveyance and end use of water appear to demand the largest portions of energy in water use, but their respective energy use will vary by water source, district location, topography, and irrigation technology, among other factors.

The energy impacts of agricultural water policy decisions may also extend beyond the energy embedded in water use. For example, in some cases, water policy decisions may affect the amount of energy used for harvest and cultivation, which can be quite large. The Westlands Water District case study shows that the energy implications of land fallowing are complicated and worthy of further study, not just in Westlands but in other settings where fallowing (permanent, dry-year, or rotational) is being considered.

Our analysis indicates that the energy impacts of fallowing farmland depend largely on where the water formerly used to irrigate that land is sent instead. From an energy perspective, a combination of conservation and water recycling may be the best path for meeting growing urban needs, while water freed up in agriculture due to efficiency improvements and fallowing might be the best source to satisfy environmental flow needs.

*From an energy perspective, a combination of conservation and water recycling may be the best path for meeting growing urban water needs.*

Finally, the Columbia case study demonstrates that foregone hydroelectric production (energy opportunity cost) can be very significant when irrigation water is diverted above power production facilities. For example, the foregone energy production in the Columbia Basin Project is the equivalent of 25 percent of the total energy use for the city of Seattle. In some cases, particularly during times of high energy prices, it may be possible to purchase water from farmers for environmental flows and finance those purchases through the additional hydropower revenues. Our analysis strongly suggests that environmental flows and quality can be enhanced in the Columbia Basin without permanent land retirement or reduction in power production, at least in some dry years.

## IMPLICATIONS OF THE CASE STUDIES

The analysis in this report supports two primary recommendations:

**Decision makers should better integrate energy issues into water policy decision making.** The background information in Chapters 1 and 2 and the case studies in Chapters 3, 4, and 5 demonstrate that looking at energy use and water use simultaneously generates valuable insights that do not arise from separate policy analyses of water and energy issues. The specific policy and planning recommendations that flow from this primary recommendation are presented below. Many of these recommendations are potentially relevant—with appropriate modification to account for differences in the policy context—outside California and the Columbia Basin.

**Water conservation should be given higher priority by policy planners in both water and energy sectors.** Although many planners in the water sector support conservation,

conservation program implementation has been slow. We conclude that conservation has much stronger economic and environmental benefits than has been recognized to date. Given this strong finding, a policy agenda for promoting water conservation is presented below.

## RECOMMENDATIONS FOR WATER RESOURCE PLANNING

Water resource planning must incorporate energy considerations. Given the close relationship between water use and energy use, water and energy policies should be managed comprehensively. State energy and environmental policies must provide consistent encouragement for cities and agriculture to invest in cost-effective energy and water demand-side strategies.

### *Federal Level*

▶ **Perform Energy Intensity Analysis.** The Bureau of Reclamation should perform an energy intensity analysis of its distribution system and identify regions and districts where large amounts of power are required to deliver water. State agencies and the Bureau of Reclamation should fully implement water-use efficiency programs in those regions and should include calculation of energy benefits in determining the cost-effectiveness of water conservation measures in those areas.

*The legislature should revise the Urban Water Management Planning Act to require water suppliers to consider the energy implications of their water management options.*

▶ **Produce a Power Balance.** The Bureau of Reclamation and the Power Marketing Authorities should produce a power balance that reconciles power generation and purchases with power consumption. There are many discrepancies between the Power Marketing Authorities and the Bureau of Reclamation data sources, which make it difficult to construct a full picture of energy generation and use. For example, given the available data, it's not possible to balance total energy resources (generation and purchases) with energy disposition (sales, consumption, and transmission losses.)

▶ **Change Energy Use Reporting Requirements.** The Department of Energy should ask manufacturers to report energy information on water heating, recirculation, pressurization, and other functions in separate categories rather than embedding that use in broader categories.

▶ **Include Energy in NEPA Evaluations.** The National Environmental Policy Act analyses for water supply issues should take particular care to address energy and related air quality impacts.

### *State Level*

▶ **Revise the Urban Water Management Planning Act.** The legislature should revise the Urban Water Management Planning Act to require water suppliers to consider the energy implications of their water management options, and to factor in related energy costs and benefits when considering water conservation measures or water supply projects.

▶ **Include Energy Intensity in Bulletin 160.** The Department of Water Resources should include a regional energy intensity analysis in Bulletin 160 and should identify ways to reduce the energy intensity of water use on a regional basis.

▶ **Integrate Energy Costs into Economic Analysis of Water Management Alternatives.** CALFED should modify this analysis to include energy costs and benefits from the various CALFED alternatives and to evaluate the economic cost of various alternatives under a variety of energy price scenarios. CALFED should carefully evaluate claims that new water storage facilities will increase net energy production.

▶ **Coordinate Among Resource Management Agencies.** The Department of Water Resources should consult with the California Energy Commission and the Public Utilities Commission on the potential energy impacts of proposed water policies. For example, the Department of Water Resources should work with the California Energy Commission to evaluate how the proposed increase in delta pumping capacity would affect total energy consumption as well as load shape.

### *Regional/Local Level*

▶ **Modify the MOU.** The California Urban Water Conservation Council should modify the MOU to require coordination with energy utilities and include energy costs and benefits in the cost-effectiveness methodology.

▶ **Investigate Energy Implications of Dry-Year Strategies.** The Metropolitan Water District of Southern California, the Department of Water Resources, and the California Energy Commission should investigate the different energy implications of dry-year strategies for Southern California, taking into consideration the premium value of energy during dry years and focusing on regional self-reliance.

▶ **Include Energy in Integrated Resource Planning.** Water agencies should include energy in their integrated resources plans. These plans should quantify the energy benefits of conservation and water recycling projects.

▶ **Reduce Energy and Environmental Impacts of Desalination.** Desalination proponents should minimize the energy and environmental impacts of desalination by: 1) looking for opportunities to use this technology on brackish and contaminated groundwater, 2) exploring desalination for use as peak or drought supply rather than base supply, and 3) seeking opportunities to reduce freshwater diversions.

### *Land Fallowing and Water Transfers in California, the Columbia Basin, and Beyond*

Land fallowing and water transfer policies under consideration in California and throughout the West should specifically address the following points:

▶ **Include Energy in Environmental Analyses.** Environmental analyses for water transfer proposals should explicitly review the energy and subsequent air quality implications of the transfer proposal. The environmental impact report for the Imperial Irrigation District–San Diego transfer did not evaluate these impacts.

▶ **Plan for Energy Costs in Environmental Water Purchases.** Purchasers for CALFED's environmental water account should include in their purchase plans the conveyance energy benefits of purchasing account water from sources south of the delta. The retirement of drainage-impaired land in the Westlands Water District presents an opportunity to save energy and provide water for environmental restoration.

▶ **Build a Consensus for Dry-Year Contingency Plans on the Columbia River.** The Bureau of Reclamation should initiate a discussion with the Power Marketing Authorities, salmon advocates, regulatory agencies, and farmers in the Northwest regarding the development of a mutually beneficial dry-year contingency plan, designed to provide benefits for agriculture, energy, and the environment along the lines of the scenario presented in Chapter 5.

▶ **Focus on Rivers with Diversions Upstream of Hydropower Plants.** Policy makers around the West should investigate the potential for dry-year partnerships on river systems where there are large water diversions upstream of hydropower facilities and degraded rivers.

## RECOMMENDATIONS FOR ADVANCING WATER CONSERVATION

Our analysis shows that the most effective way to reduce energy related to water use is to consume less water. In addition to reducing the energy required for end use, conservation eliminates all of the upstream energy required to bring the water to the point of use, as well as all of the downstream energy that would otherwise be consumed to treat and dispose of this water. In many cases, conservation provides the most cost-effective water supply option, particularly once energy costs are included. The federal, state, and local governments, as well as water and energy utilities, should prioritize conservation. To increase conservation, decision makers should:

*In many cases, conservation provides the most cost-effective water supply option, particularly once energy costs are included.*

### *Conservation Funding*

▶ **Prioritize Conservation Funding.** State, federal, and local budget problems will limit the availability of public funding for many programs. Nonetheless, investment in conservation may forestall or avoid larger public investments for drinking water, clean water infrastructure, or power generation facilities, and it will help stretch available funds.

### *Conservation Requirements*

▶ **Implement Existing Requirements.** The Bureau of Reclamation should implement the water conservation planning requirements of the Central Valley Project Improvement Act and Reclamation Reform Act.

▶ **Ensure Compliance with the MOU.** The Department of Water Resources should require anyone receiving water from the State Water Project, directly or indirectly, to fully implement the terms of the Memorandum of Understanding Concerning Urban Water Conservation in California.

### *Water Measurement and Pricing*

▶ **Enact Universal Measurement Legislation.** All water use in the state, including surface and groundwater, should be measured, and water users should be charged for each unit of water they use. This is a precondition for efficient water use. The CALFED Authority should meet its commitment to develop legislation requiring appropriate measurement of water use for all water users in California.[117] This legislation should require:

- ▷ Measurement and volumetric billing of all urban and agricultural water use;
- ▷ Dedicated meters for large landscapes;
- ▷ Submetering of multi-family housing.

▶ **Conduct Groundwater Monitoring.** The CALFED Authority should develop and the legislature should adopt groundwater monitoring legislation to improve management of this unregulated resource.[118]

*The CALFED Bay-Delta Authority should require full implementation of conservation measures, including water measurement and volumetric pricing, as a prerequisite for receiving any program benefits.*

▶ **Eliminate Subsidies.** The federal government should phase out irrigation, energy, and crop subsidies, which encourage wasteful use of water and energy, as well as cultivation of low-value crops and cultivation of marginal lands where irrigation contributes to water quality problems.

▶ **Establish Wastewater Volumetric Pricing.** The legislature should pass legislation requiring wastewater agencies to bill their customers volumetrically. Flat rates for wastewater fail to deliver a price signal to customers to reduce their indoor water use. Volumetric billing of wastewater is already endorsed by Best Management Practice 11 in the Urban MOU. This measure has strong precedent in other states: in Texas and Florida, more than 97 percent of sewer rates are volumetric and in Arizona 68 percent are volumetric. In California, only 13 percent of the state's wastewater treatment providers bill by volume.

▶ **Require Dedicated Meters for Large Landscapes.** The legislature should pass AB 2298 (Plescia), requiring dedicated meters to measure landscape water use. This complements Best Management Practice #5 in the Urban MOU, and would provide a valuable conservation tool for water agencies and landscape managers.

▶ **Establish Rates for Outdoor Water Use.** Water agencies should establish seasonal or tiered water rates to target outdoor water use. The Urban MOU has not yet successfully addressed outdoor water use. Rate structures are an effective tool for targeting outdoor water use.

### *Conservation Incentives*

▶ **Tie CALFED Benefits to Conservation.** The CALFED Bay-Delta Authority should require full implementation of conservation measures, including water measurement and volumetric pricing, as a prerequisite for receiving any program benefits.

▶ **Broaden Energy Conservation Programs.** Energy utilities should broaden their water conservation efforts to include all water use, not just the conservation of heated water.

▶ **Pursue Conservation above the MOU.** The CALFED Bay-Delta Authority and its member agencies should develop programs targeted at obtaining water conservation savings beyond the levels specified in the MOU. The MOU does not require implementation of all cost-effective conservation. Indeed, while much of the focus in CALFED and elsewhere tends to be on implementation of the best management practices, there remain significant cost-effective conservation savings beyond those practices.

▶ **Link Loans to Conservation Achievements.** The State Board and Department of Health Services should tie clean-water and drinking-water revolving-fund loans to conservation achievements. The state operates two federally authorized revolving funds that provide loans to local agencies for certain drinking water and wastewater infrastructure investments. California's total estimated needs for these expenditures is approximately $30 billion. A large percentage of these needs are flow-related and could be delayed or reduced if projected flows or volumes were reduced through conservation. As a condition to granting revolving-fund support, the State Board and Department of Health Services should require applicants to demonstrate that all projects for which funding is being sought have been sized and timed to account for full implementation of conservation programs.

### *Conservation Assurances*

▶ **Adopt Best-Management-Practice Certification.** The CALFED Authority should adopt a best-management-practice certification process for urban conservation with consequences for noncompliance.[119]

▶ **Establish Agricultural Water-Use Efficiency Objectives.** The Department of Water Resources should finalize the remaining quantitative objectives for agricultural water use efficiency and an assurances package that includes consequences for failing to meet those objectives. The Department of Water Resources should conduct the overdue evaluation of progress toward meeting the quantitative objectives.

▶ **Verify Water Savings.** The Department of Water Resources must include a monitoring component in all water conservation grants to verify conservation savings and track disposition of conserved water. Expediting distribution of funds should not take precedence over good science.

▶ **Revise the Cost-Benefit Analysis.** The Department of Water Resources should revise the cost-benefit methodology required as part of the water-use efficiency grant process to require inclusion of energy costs and benefits.

▶ **Pass a Retrofit-Upon-Resale Law.** The state legislature should adopt a retrofit-upon-resale law requiring replacement of inefficient toilets with ultra low-flow toilets upon sale of a home. Such ordinances are in effect in Los Angeles, Santa Monica, San Diego, and other cities. The Urban MOU requires signatories to adopt programs that are at least as effective as a retrofit-upon-resale ordinance, but to date, few programs have achieved that level of implementation. The California real estate

market remains incredibly strong, and a retrofit-upon-resale requirement would have little impact on this market.

▶ **Improve the Model Landscape Ordinance.** The existing model landscape ordinance, developed in response to AB 325, is deficient in several respects. The California legislature should pass legislation to revise and improve the model ordinance.

## AREAS FOR ADDITIONAL RESEARCH

Our research highlighted several areas where additional data could improve energy intensity analysis and facilitate the integration of energy considerations in water policy. Some of these are listed below:

▶ **Investigate Evaporative and Conveyance Losses.** The California State Water Project, the Central Valley Project, and water districts, agencies, and companies should conduct analyses of evaporative and conveyance losses throughout their systems, not just in large canals, aqueducts, and distribution piping.

▶ **Go Beyond Appliances.** The Department of Energy or another party should analyze energy use integral to end use of water beyond domestic fixtures and appliances.

▶ **Fund Research in Water Use Efficiency.** The Department of Water Resources should fund research to address remaining areas of uncertainty in water use efficiency, including the relationship between evaporation and transpiration and the potential for reducing irrecoverable losses through reductions in evaporation.

▶ **Study the Link Between Water Policy and Emissions.** The Department of Water Resources or another party should extend the models presented in this report to estimate changes in air emissions resulting from water policy decisions. Demonstrating the linkage all the way through to air quality would greatly strengthen the policy recommendation that water management decisions should account for the energy dimension.

▶ **Examine the Climate Change Implications for Water Policy.** The Department of Water Resources and the California Energy Commission should evaluate the climate change implications of water policy.

APPENDIX A

# URBAN MODEL DESCRIPTION

We have modified and expanded the methodology of Wilkinson into a user-friendly spreadsheet to determine the energy embedded in water use from source to disposal.[120] Filling out the spreadsheets completely would require full information about actual and potential water and water-related energy use in San Diego County. Full information is never available in practice, but the information gaps that will exist are not known in advance, so this type of spreadsheet is the best analytical starting point. Note that the spreadsheets include water sources that are being considered for San Diego but are not actual (e.g., seawater desalination, transfer from the Imperial Irrigation District, and water bags towed by sea from Northern California).

The eight Excel spreadsheets we used are organized in three layers (see Figure A-1):

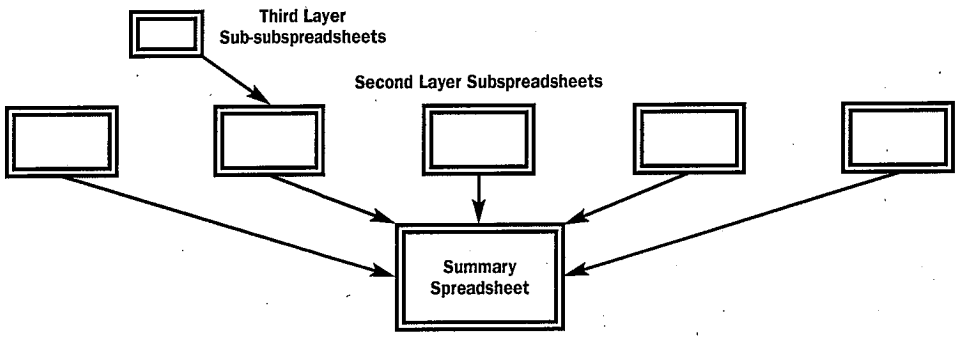
1. One summary spreadsheet.

2. Five subspreadsheets, one each for sources, water treatment, water distribution, end use, and wastewater treatment. Water recycling projects are considered to be sources of water. Their energy use consists of the energy required to upgrade water from discharge-suitable quality into reuse-suitable quality.

3. Two sub-subspreadsheets, one each for groundwater sources and water recycling sources.

Copies of the spreadsheets are available from Pacific Institute.

**FIGURE A-1**
**Diagram of the Flow Between Spreadsheets**



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August 2004

The summary spreadsheet does not allow for data input, while the other seven spreadsheets require data input. All eight spreadsheets perform calculations. The five steps in the water-supply-use-disposal chain fix the number of spreadsheets in the second layer. The number of the third-layer spreadsheets depends on the circumstances. Each third-layer spreadsheet allows the user to assemble disaggregated data about one aggregate item in a second-layer spreadsheet. For example, the groundwater spreadsheet contains data on various groundwater sources that are aggregated into a single column in the sources and conveyance spreadsheet.

## SUMMARY SHEET (TOP LAYER)

The summary spreadsheet does not allow inputs, and incorporates data directly from the penultimate spreadsheets (and indirectly from the subpenultimate spreadsheets). Here, the user can gain an overview of the energy embedded in water use as a function of the five principal energy components of urban water cycles. The effect of new water sources or conservation measures on energy use can be analyzed in the summary spreadsheet through changes in the data inputs of the other spreadsheets.

Row 5 summarizes the volume of water that enters each of the five principal energy components. Decreases in volume that occur between the first (sources and conveyance) and last (wastewater collection and treatment) of these components reflects water loss (both consumptive and nonconsumptive) that occurs during the water cycle. Row 6 summarizes the average annual energy use for each of the five steps in the supply-use-disposal chain, with total energy use summed across the five components presented in column K. Because these are total energy use figures for each component, their sum is an accurate number—it reflects total energy use in the chain based on the mix of supplies, the level of conservation, and so forth, input to the other spreadsheets.

Row 7 calculates the energy factor, a ratio of energy consumed (kWh/yr) to water consumed for end uses (af/yr), thus normalizing energy consumption per unit across the five principal energy components. The total of the energy factors for row 7 is in column K. Row 8 reports the energy factors as percentages and contains the data used to create "The Percent Energy Use in the Five Components of Urban Water Systems" graph. This graph visually depicts the percentage energy use by the urban water system component and helps to show where energy is being consumed under the assumptions that have been input. Although the first summary spreadsheet that a user of the model creates should reflect actual conditions, one can examine counterfactual scenarios by changing the inputs in the penultimate and subpenultimate spreadsheets.

## SUBSPREADSHEETS (SECOND LAYER)

We have organized this layer of spreadsheets according to the five steps described previously: 1) sources and conveyances, 2) water treatment, 3) distribution, 4) end use, and 5) wastewater collection and treatment. Each subspreadsheet has a similar

format and requires three types of data: 1) average annual volume (in af/yr) of water "in," 2) average annual energy use (in kWh/yr), and 3) percentage of water loss. Several spreadsheets require additional data and are noted as such in the following descriptions.

### Sources and Conveyances

This category represents the energy required for the extraction of raw water from its source and the conveyance of water to the site of treatment, either via pumping or water transport (e.g. water bags). For example, it requires more than 3,200 kWh/yr of energy to pump water from intakes in the delta through the State Water Project to San Diego (row 8, column C). For water recycling and desalination, this category includes the energy required to extract usable water from wastewater, brackish water, or salt water. San Diego potentially obtains water from the seven sources and conveyances listed as columns in this spreadsheet.

For each source and conveyance, the following inputs are required and calculations are performed. The average annual water supplied (in acre-feet) from each source and conveyance is input and is summed across to obtain a total average annual water supply (row 5, column K). Using the data from row 5, row 6 calculates the percentage of water supplied by each source and conveyance. The cells in row 6 are locked, meaning the user cannot change the percentage of water supplied by each source and conveyance. Users may investigate how changing the water supply and conveyance portfolio (i.e. percentage of water supplied by each source and conveyance) affects energy use by changing the water supply data in row 5. Users may also change the total average annual water supply (but keep the water supply and conveyance portfolio constant) to investigate how absolute rather than relative changes affect energy use.

The percentage of water loss that occurs after removal from a source and/or during conveyance may be input into row 7. This is useful information if available, but is not necessary for the calculations leading to the summary spreadsheet. If water "in" is input for all cells in all the spreadsheets, percent loss is the difference between water "in" to one step of the chain and water "in" to the next step of the chain. The input for percentage of water loss here provides an alternative method for estimating the amount of water into the next step in the chain if the user is unable to obtain "in" data for the next step (in this case, water treatment).

The average annual energy use (in kilowatt-hours) required for each source and conveyance is input in row 8 and is summed across sources and conveyances to obtain total average annual energy use (row 8, column K). Row 9 allows for the user to enter comments regarding the quality of the water supply should there be any unusual aspects of a water source and conveyance. The quality of raw water will often affect energy used to treat it, with more than average energy used if raw water is brackish and less than average energy used if raw water is from a desalting facility or very high-quality natural source.

The groundwater sources and water reuse columns are calculated from sub-penultimate spreadsheets described below. These subspreadsheets keep the sources

and conveyance spreadsheet manageable. We recommend using a subspreadsheet when more than two facilities exist for a column in a penultimate spreadsheet.

### *Water Treatment*

This category represents the energy required for the processes that occur within a water treatment facility to obtain treated water that meets potable water health standards. Often, filtration or flocculation and sedimentation, followed by disinfection, are adequate. There are 10 water treatment facilities that process water treated in San Diego County. In addition, the Metropolitan Water District delivers treated water from the Skinner treatment plant in Riverside County. For simplicity, the model structure assumes that the location of the treatment facility (e.g., in the county or out of the county) does not affect the energy used to convey and distribute water to customers.[121]

The inputs required and calculations performed for the water treatment spreadsheet are the same as those for the sources and conveyances spreadsheet. As in the sources and conveyances spreadsheet, the user can enter information regarding water quality, highlighting the variation in energy factors across plants.

### *Distribution*

This category represents the energy required for any pressurization or pumping that occurs as treated water leaves the water treatment facility and for the transport of treated water through the distribution blocks. There are many distribution zones within San Diego County. Note that the spreadsheet is constructed as if each distribution zone conveys water from one or more treatment plants to end users. If water were to pass through two distribution zones between treatment plant and end users, the spreadsheet would need to be modified to account for energy use "in series" rather than "in parallel."

The distribution spreadsheet does not allow for the user to enter notes regarding water quality. The assumption is that all water is of the same quality (i.e., treated to potable standards). Otherwise, the inputs required and calculations performed are the same as those for the sources and conveyances spreadsheet.

### *End Use*

This category represents the energy required for all end uses; i.e., those that are measured via metered water consumption. Urban water users are primarily those in the municipal and industrial sector. For the general spreadsheet, we divide water use into the two large categories typical of urban water supply planning: 1) residential and 2) commercial, industrial, and institutional (CII). We further subdivide residential use into categories that apply throughout the western United States: clothes washers; dishwashers; showers, tubs, and faucets; toilets; turf landscape; and non-turf landscape. We do not subdivide CII uses at this time.

The inputs required and calculations performed for the end use spreadsheet are the same as those for the sources and conveyances spreadsheet, with the exception that average annual energy use includes kilowatt-hours actually used plus thermal energy converted to kilowatt-hours at a heat rate of 10,239 British thermal units

per kilowatt-hour. This conversion represents the electrical energy that could be produced at average thermal power plant efficiency if thermal energy were in fact converted to electricity prior to use. This is necessary to report total energy intensity numbers (equivalent kilowatt-hours), but should not be misinterpreted as actual kilowatt-hours used in any category.

Energy use during end use is in addition to the energy used to pressurize water in distribution systems. Some end uses do not use additional energy. For example, flush toilets with gravity sewers do not use additional energy, so the cell for energy use by toilets contains a zero value. Similarly, irrigation systems that operate solely from distribution pressure do not use additional energy unless they have electrically operated valves or control systems. In contrast, any use of hot water involves additional energy, as do appliances that include motors, pumps, automatic valves, timers, and so forth (e.g., clothes washers or recirculating pumps at car washes).

In this sense, end use energy is no different than source and conveyance, treatment, distribution, and disposal energy. It is one of five parts of a chain of energy uses that must be added to obtain total energy use associated with each acre-foot of water used by customers.

However, end use represents a unique step among the five parts of the supply-use-disposal chain. It is the only step where conservation saves energy in the other four steps. Reducing water losses in conveyance will reduce the amount of energy associated with each acre-foot delivered. But it will not reduce total energy consumed in other steps if water delivered to customers is held constant. Reductions in distribution losses (the biggest part of "unaccounted-for water") are similar. But reductions in water consumption will affect total energy use in all five parts of the chain, even though it may not reduce the amount of energy associated with each acre-foot of use.

Stated another way, total energy use depends on the average energy factor of a system (average kWh/af delivered to customers) and the total water consumption of the system (acre-feet). Conservation doesn't necessarily affect the average energy factor, although it may, but it will always affect total energy use. Many water conservation technologies also reduce energy use, so conservation will often save energy in total and pull down the average energy factor of the system. However, some water conservation measures use more energy than pre-conservation practices, driving up the average energy factor of the system. But even if the average energy factor is driven up because energy is being substituted for water, speaking in the jargon of economics, total energy use can still decline because the increased energy in end use may be smaller than the energy savings from reducing the customer's need for water.

The linked spreadsheets account for these possibilities. First, one inputs average energy use associated with water use in each category (e.g., CII) or subcategory (e.g., clothes washers). Then, when considering implementation of water conservation measures, one both reduces total end use of water by the amount of conservation and adjusts the energy use in each end use category and subcategory to reflect energy use after implementation of that amount of conservation. The adjusted energy use inputs may be higher or lower than before conservation. If lower, the

average system energy factor and total system energy consumption will decline. If higher, the average system energy factor will increase but total system energy consumption may increase or decrease.

### *Wastewater Collection and Treatment*

This category represents the energy required for the transport of wastewater to the wastewater treatment facility—lift requirements are significant in many places and all wastewater treatment processes, which usually consist of a series of physical processes (e.g., pumping, screening, and filtration), chemical processes (e.g., chlorine addition), and biological processes (e.g., microbial removal of contaminants) to prepare wastewater and waste solids for release back into the environment. San Diego County has 14 wastewater treatment facilities.

The wastewater collection and treatment spreadsheet is similar to the other spreadsheets with respect to data input and calculations; any unusual wastewater treatment requirements can be noted in the bottom row.

## SUB-SUBSPREADSHEETS (THIRD LAYER)

The sub-subspreadsheets perform calculations, the results of which feed into the subspreadsheets. Thus, the subspreadsheets remain streamlined with a consistent format while background calculations are conducted in the sub-subspreadsheets. Based on our evaluation of San Diego County, we believe that two spreadsheets in the third layer are adequate to model any water system. Another spreadsheet for local reservoirs might be necessary if energy use or production from those reservoirs were significant. In San Diego County, however, energy used to charge the reservoirs with imported water is included in the import columns of the source and conveyance spreadsheet, and energy production from the reservoirs is reported to be very small. This is typical for relatively small terminal reservoirs in a system that depends heavily on imported water.

### *Groundwater Sources*

The objective of this spreadsheet is to determine the average annual volume of water that comes from each of the groundwater sources (row 5) and the average annual energy use associated with each groundwater source (row 7). Energy requirements are due primarily to pumping and conveyance of groundwater. Groundwater pumps are either electric or gas; if they use gas, energy use in therms is converted into kilowatt-hours (row 6). Row 8 allows the user to input information regarding the quality (e.g. brackish water, seawater) of the groundwater source if it is unusual. The weighted averages from the groundwater sources spreadsheet are linked to the groundwater column in the sources and conveyances spreadsheet.

### *Water Reuse Projects*

The objective of this spreadsheet is to determine the average annual volume of water (row 5) that comes from each of the water recycling projects and the average annual

energy use associated with water recycling (row 7). Energy requirements are due primarily to pumping and conveying recycled water. Row 8 allows the user to input data regarding the water quality associated with each water reuse project. The results from the water reuse projects spreadsheet are linked to the water reuse column in the sources and conveyances spreadsheet.

San Diego has 24 water reuse projects; the water from these projects is primarily used for agriculture, landscaping, and irrigation purposes. Note that this is the energy used to upgrade water from a quality level adequate for legal discharge to the quality level required for reuse. Energy used to treat wastewater to discharge quality is included in the wastewater collection and treatment subspreadsheet.

APPENDIX B

# SAN DIEGO CASE STUDY DATA SOURCES AND ASSUMPTIONS

▶ The State Water Project (SWP) pumping energy is from Wilkinson.[122] Flow from Devil's Canyon to the San Diego County Water Authority (SDCWA) is assumed to be by gravity via Lake Perris, the Diamond Valley Lake, or Lake Skinner. Energy intensity is assumed to be for water delivered to Devil's Canyon. That is, water losses in the SWP are already accounted for in this energy intensity figure.

▶ The Colorado River Aqueduct (CRA) pumping energy is from Wilkinson.[123] Flow to the SDCWA is assumed to be by gravity via Lake Mathews, the Diamond Valley Lake, or Lake Skinner. Energy intensity is assumed to be for water delivered to Lake Mathews, or equivalent.[124] That is, water losses in the CRA are already accounted for in this energy intensity figure.

▶ Water-bag towing expenditures are for diesel fuel energy from Spragg for a 400-mile round-trip from the Mad River to Monterey, adjusted for a 900-mile round-trip from the Mad River to San Diego.[125] Energy expenditures were converted to kilowatt-hours equivalent using $1.50 per gallon, 150,000 BTU per gallon, and 10,239 BTU required to produce each kilowatt-hour.

▶ Hydroelectricity is not produced in the Colorado River between the intake of the CRA and the intake of the All American Canal.[126]

▶ Hydroelectric power not produced in the All American Canal if water were transferred to San Diego is based on an average of 2.85 million af/yr of flow in the canal and an average of 3 million kWh/yr of hydroelectricity produced from that flow.[127] Adjusting for an assumed 5 percent loss of water in the CRA, these figures yield 110 kWh lost per acre-foot delivered to San Diego County.

▶ Energy use per acre-foot for the SDCWA Seawater Desalination Facility at Encina is from SDCWA staff.[128]

▶ Raw water lift to treatment plants is from SDCWA. Staff provided data for the Levy and Perdue water treatment plants.[129] It is assumed to be representative of other plants in the county and the Skinner treatment plant operated by the Western Municipal Water District in Riverside County.

▶ Groundwater lift data are from SDCWA. Staff provided data for the Yuima Municipal Water District and the Sweetwater Authority.[130]

▶ Energy use in water recycling is from SDCWA. Staff provided data for supplemental treatment at San Elijo and Santee Basin and brackish groundwater treatment at Reynolds.[131]

▶ Energy use in water treatment is from SDCWA. Staff provided data for Vista (Escondido), Levy, and Perdue water treatment plants.[132]

▶ Water loss in water treatment was assumed to be 5 percent based on calculations at the Perdue (Sweetwater) treatment plant.[133]

▶ Energy use in water distribution is from the Helix Water District's distribution system from the Levy treatment plant and the North City recycled water system.[134] Note that about half the distribution system flow from Levy is pressurized by gravity, so pump pressurization requirements are higher per acre-feet than the figures used. Our analysis uses the weighted average figure because, according to SDCWA staff, significant portions of the distribution system in San Diego County are pressurized by gravity.[135]

▶ Distribution loss (unaccounted-for water) is assumed to be 7 percent based on one estimate of the sum of losses in regional distribution and local distribution provided by SDCWA staff.[136]

▶ Water use in the SDCWA service area in 2010 is projected to be 32 percent CII (commercial, industrial, and institutional uses); 58 percent residential (41 percent single-family, 17 percent multi-family); and 10 percent agricultural, according to SDCWA staff.[137] Our analysis assumed these figures are also roughly representative of current use.

▶ Residential water use is assumed to be 60 percent indoor, 40 percent outdoor.[138]

▶ Indoor use is further disaggregated according to the Awwa Research Foundation: toilets, 26.1 percent; clothes washers, 22.7 percent; showers, 17.8 percent; faucets, 15.4 percent; leaks, 12.7 percent; baths, 1.8 percent; dishwashers, 1.4 percent; other, 2.1 percent.

▶ CII use was disaggregated as in Gleick et al: 38 percent landscaping, 6 percent kitchen (composed of 24 percent dishwashers, 14 percent pre-rinse nozzles, 62 percent other kitchen), 15 percent cooling, 14 percent restroom, 18 percent process, 2 percent laundry, and 7 percent other.[139]

▶ Energy use in clothes-washers and dishwashers are averages from the Department of Energy's Energy Star website.[140] Energy use in showers and baths assumes heating from 60 to 105 degrees Fahrenheit; faucet water is conservatively assumed to be unheated.

▶ All dishwasher energy savings are assumed to be from reduced consumption of hot water; three-quarters of clothes-washer savings are assumed to be from reduced consumption of hot water.[141]

▶ Water-cooled chiller energy consumption of 0.5 kWh/ton from the Federal Energy Management Program website.[142]

▶ Evaporative water consumption and the ratio of evaporative consumption to blowdown in water-cooled chillers from city of San Jose.[143]

▶ CII energy use for water heating from Sezgen and Koomey.[144]

▶ Energy use in industrial wastewater treatment in the United States is from Amarnath,[145] conservatively assuming the reported $2.5 billion of annual fuel and energy expenditures for treatment were for diesel fuel or gasoline at $1.50 per gallon, with heat content of 150,000 BTUs per gallon.[146]

▶ Industrial water use for the United States also from Amarnath, but cross-checked against United States Geological Survey Circular 1081.[147]

▶ Energy use in wastewater treatment is from SDCWA. Staff provided data for the North City and Santee Basin facilities.[148] Note that energy intensity per acre-foot treated is significantly higher than the energy intensity presented in Figure 4 because the latter is energy intensity per acre-foot of end use. Only 46 percent of countywide water use is estimated to enter the wastewater system because landscape and agricultural water use, pipe leaks, and some CII processing and cooling water are not tributary to wastewater treatment plants.

APPENDIX C

# AGRICULTURAL MODEL DESCRIPTION



The agricultural model structure is parallel to the urban model presented in Appendix A. However, a number of modifications were required to account for differences between urban and agricultural settings. Some of the differences include:

- Sources other than surface and groundwater, recycled water, and conservation are rarely used for agriculture. For example, desalination for agricultural use is unheard of. The economic value of agricultural products is not high enough to justify the more expensive sources of water used in urban settings.
- Water for agriculture is rarely treated unless it is reclaimed from a wastewater source.
- Hydroelectric production opportunities and trade-offs are often more complicated for agricultural water than urban water.
- Agricultural water is often distributed to end use (the plants in the fields) by gravity in open channels, although pressurized distribution via sprinklers or drip irrigation systems is also common. Often, water is lifted a short height—such as 10 feet—from the distribution canal to the field.
- On-farm redistribution from irrigation-tailwater-return ponds is growing in popularity as a way of conserving water and reducing discharge of pollutants. The urban analogy is on-site water reuse by industry. However, industrial water reuse usually involves treatment, while on-site agricultural reuse usually does not.
- The water quality standards for recycled wastewater intended for agricultural reuse are lower than for urban reuse, which implies less energy consumption per unit of water recycled. Recycling wastewater for agricultural purposes is common in the western United States, especially in landlocked areas where discharge to receiving waters is restricted either during the dry season or year-round.

There is no treatment spreadsheet since agricultural water is not treated between source/conveyance and distribution. As in the urban model, distribution is separated into generic blocks. End uses are defined as crop type/irrigation system combinations. For example, one could grow almonds with flood irrigation or with permanent sprinklers. Energy for pressurizing the sprinklers or lifting water from edge-of-farm canals is included in end use energy, not in distribution energy. In

concept, a spreadsheet for drainage management would replace the wastewater treatment spreadsheet in the urban model. In the Westlands Water District, however, drainage management other than tailwater-return ponds does not use energy. Tailwater-return energy use is accounted for in the third-layer water-reuse spreadsheet that feeds the sources and conveyances spreadsheet. The groundwater spreadsheet is conceptually identical to the urban model.

# ENDNOTES

1 The use of water in producing energy is an important subject but is beyond the scope of this report. For information on this issue see, for example Ellen Baum, et al., *The Last Straw: Water Use by Power Plants in the Arid West*, (Boston: The Clean Air Task Force and the Land and Water Fund of the Rockies, 2003).

2 California Water Code, Section 522.

3 California Energy Commission, *Agricultural Rates in California* (Sacramento, California: California Energy Commission, 2001), p. 9.

4 Electric Power Research Institute, *Energy Audit Manual for Water/Wastewater Facilities*, (Palo Alto: 1999), Executive Summary.

5 There are 11.5 million households in California (U.S. Census). Each of these households consumes an average of 6,500 kWh/yr. "California Energy Consumption by Sector," available at http://energy.ca.gov/electricity/consumption_by_sector.html.

6 Nathanael Greene and Roel Hammerschlag, "Small and Clean Is Beautiful: Exploring the Emissions of Distributed Generation and Pollution Prevention Policies," in *The Electricity Journal*, June 2000, pp. 50–60.

7 Frank Burton, *Water and Wastewater Industries: Characteristics and Energy Management Opportunities* (Palo Alto, CA: Electric Power Research Institute, 1996), pp. 3–9.

8 Robert C. Wilkinson combines treatment and distribution; i.e., he divides the water chain into four stages in *Methodology for Analysis of the Energy Intensity of California's Water Systems, and an Assessment of Multiple Potential Benefits Through Integrated Water-Energy Efficiency Measures* (Santa Barbara, CA: University of California, Santa Barbara, Environmental Studies Program, 2000).

9 Electric Power Research Institute, Executive Summary.

10 Carrie Anderson, *Energy Use in the Supply, Use, and Disposal of Water in California*, (Sacramento: California Energy Commission, 1999), p.9.

11 "Power Plants Kill Billions of Fish," available at: www.riverkeeper.org/campaign.php/fishkills/the_facts/178. For additional information on the impacts of power plants on aquatic resources, see, for example, Peter Raimondi's testimony before the Central Coast Regional Water Quality Control Board, July 10, 2003, entitled "Cooling Water System: Findings Regarding Clean Water Act Section 316(b), Diablo Canyon Power Plant." This testimony is available at: www.swrcb.ca.gov/rwqcb3/Facilities/Diablo/Diablo.htm.

12 For more information on these impacts see, for example, Bruce Driver and Gregg Eisenberg, *Western Hydropower: Changing Values/New Visions, Independent Report to the Western Water Policy Review Advisory Commission* (Boulder, CO: 1997); and Phillip Williams, "The Flood Next Time: Restoring Living Rivers," in *World Rivers Review*, February 2000, p. 6.

13 For further discussion of global climate change and its impacts on water supply, see Peter H. Gleick and D. Briane Adams, *Water: The Potential Consequences of Climate Variability and Change for the Water Resources of the United States, the Report of the Water Sector Assessment Team for the U.S. Global Change Research Program* (Oakland, CA: Pacific Institute, 2000); Victor S. Kennedy, et al., *Coastal and Marine Ecosystems and Global Climate Change: Potential Effects on U.S. Resources* (Arlington, VA: Pew Center on Global Climate Change, 2002); Jay R. Lund, et al., *Climate Warming and California's Water Future* (Davis, CA: Department of Civil and Environmental Engineering, University of California, 2003), Kirkman O'Neal, *Effects of Global Warming on Trout and Salmon in U.S. Streams* (Washington, DC: Defenders of Wildlife, 2002); N. Leroy Poff and Mark Brinson, *Aquatic Ecosystems and Global Climate Change: Potential Impacts on Inland Freshwater and Coastal Wetland Ecosystems in the United States* (Arlington, VA: Pew Center on Global Climate Change, 2002); and *Confronting Climate Change in California: Ecological Impacts on the Golden State* (Cambridge, MA: Union of Concerned Scientists, 1999).

14 *Climate Changes the Water Rules: How Water Managers Can Cope With Today's Climate Variability and Tomorrow's Climate Change* (Delft, The Netherlands: The Dialogue on Water and Climate, 2003). This collaborative report is available at: www.waterandclimate.org/report.htm.

15 Peter H. Gleick and Linda L. Nash, *The Societal and Environmental Costs of the Continuing California Drought* (Oakland, CA: Pacific Institute, 1991).

16 A full discussion of water and power subsidies is beyond the scope of this report. For more information on the magnitude of these extensive subsidies, see, for example, Norman Myers and Jennifer Kent, *Perverse Subsidies: How Misused Tax Dollars Harm the Environment and the Economy* (Washington, DC: Island Press, 1998); Committee on Natural Resources, *Taking from the Taxpayer: Public Subsidies for Natural Resource Development* (Washington: U.S. Government Printing Office, 1994); B. Delworth Gardner, *Plowing Ground in Washington: The Political Economy of U.S. Agriculture* (San Francisco: Pacific Research Institute for Public Policy, 1995); Ronald Bailey, ed., *The True State of the Planet* (New York: Competitive Enterprise Institute, 1995); and Dr. E. Phillip LeVeen and Laura B. King, *Turning Off the Tap on Federal Water Subsidies* (New York: NRDC, 1985).

17 Committee on Natural Resources, p. 64.

18 Committee on Natural Resources, p. 66.

19 The Central Valley Project no longer charges a power rate for its water deliveries. In part, this seems to be because it does not want to be subject to oversight by FERC or other agencies. Instead, the Central Valley Project includes a per-acre-foot power charge for water deliveries. The per-acre-foot energy rates vary widely from contractor to contractor, ranging from one penny to $4.96 per acre-foot. Jesus Reynoso, Water Rate-Setting Section, United States Bureau of Reclamation Finance Office, personal communication, April 2003.

20 *Mid-Pacific Region 1999 Irrigation Water Rates, Central Valley Project* (Sacramento, CA: U.S. Bureau of Reclamation, Mid-Pacific Region, 1999).

21 B. Delworth Gardner, *Plowing Ground in Washington: The Political Economy of U.S. Agriculture* (Pacific Research Institute for Public Policy), p. 296.

22 Our San Diego case study shows that about 2,100 kWh/af will be required to support the transfer. About 5 percent of this amount (100 kWh/af) is hydroelectricity not produced in the All American Canal; the other 2,000 kWh/af are used as electricity to pump the transferred water through the Colorado River Aqueduct. Each 100,000 af/yr of water transferred to San Diego, therefore, may increase electricity demand by 210 million kWh/yr. This is certainly not negligible, and should have been discussed in the environmental impact review.

23 S. Joshua Newcom, "Dealing with the Shock: Shedding Light on the Link Between Water and Power in California," in *Western Water*, September/October 2001, p. 7.

24 Wilkinson, p. 6.

25 Surface and groundwater figures come from Department of Water Resources, *Bulletin 160-98*; recycled water figure comes from Department of Water Resources, *Water Recycling 2030: Recommendations of California's Recycled Water Task Force*, 2003; desalination figure comes from Department of Water Resources, *Bulletin 160-03*, 2003 stakeholder draft.

26 Carrie Anderson, *Energy Use in the Supply, Use, and Disposal of Water in California* (Sacramento: California Energy Commission, 1999) p. 1.

27 Wilkinson, p.7.

28 Steve Kashiwada, State Water Project, personal communication, June 2002.

29 Barry Mortimer, Central Valley Project, May 2002, and Steve Kashiwada, State Water Project, personal communication, June 2002.

30 Larry Dale, et al., *The Impact of Electricity Prices on the Cost of Five Options to Increase Southern California's Urban Water Supplies* (prepared for NRDC, 2003), p. 4.

31 Anderson, p.4.

32 Larry Dale, et. al., 2003.

33 California Energy Commission, p. 16.

34 Department of Water Resources, *California Water Plan Update 2003–Stakeholder Draft*, (Sacramento, CA: 2003).

35 *Seawater Desalination and the California Coastal Act (DRAFT)* (Sacramento, CA: California Coastal Commission, 2003).

36 John Kiernan, personal communication, March 2003.

37 Wilkinson.

38 Ibid.

39 Barakat & Chamberlin, Inc., *The Value of Water Supply Reliability: Results of a Contingent Valuation Survey of Residential Customers* (Sacramento, CA: California Urban Water Agencies, 1994).

40 The Ocean Conservancy, *Desalination: An Overview*, prepared for May 5, 2003, Environmental Roundtable Meeting in San Francisco.

41 California Water Code Section 13050 (n).

42 Department of Water Resources, Recycled Water Task Force, *Water Recycling 2030: Recommendations of California's Recycled Water Task Force*, (Sacramento: June 2003), p.7.

43 Ibid., p.5.

44 Ibid., p.5.

45 Newcom, p.12.

46 "Water Pipeline Project Underway in Orange County," Orange County Water District Press Release, February 19, 2004, available at: http://www.gwrsystem.com/news/releases/040219.html.

47 Burton, pp.3–30. In addition to direct energy costs for water treatment, substantial energy is also required to produce the chemicals used for water treatment. Those costs, while beyond the scope of this report, are part of the life-cycle energy costs of water.

48 Burton, p. ES–5.

49 Burton, p. ES–4.

50 Burton, pp. 3–9.

51 Burton, pp. 3–27.

52 *Draft WUE Program Plan* (Sacramento, CA: CALFED Bay-Delta Program, 1999), pp.5–21.

53 National Renewable Energy Laboratory, "Cities Cut Water System Energy Costs," 1994.

54 Irrigation Training and Research Center, *Variable Frequency Drives and SCADA—Are They Worthwhile Investments?* ITRC Report 02-006 (San Luis Obispo, CA: California Polytechnic State University, 2002).

55 Gleick, et al., p.3.

56 Gleick, et. al., p.2.

57 Peter W. Mayer, et al., *Residential End Uses of Water* (Denver, CO: American Water Works Association Research Foundation, 1999).

58 Tables 3 through 5 modified from Amy Vickers' *Handbook of Water Use and Conservation: Homes, Landscapes, Business, Industries, Farms* (Amherst, MA: WaterPlow Press, 2001).

59 Gary H. Wolff and Peter H. Gleick, "The Soft Path for Water," in *The World's Water: The Biennial Report on Freshwater Resources* (Washington, DC: Island Press, 2002).

60 For a complete discussion of residential conservation measures, see Vickers, and Gleick, et.al., 2003.

61 *Codes and Standards Enhancement Initiative For FY2003: Title 20 Standards Development, Comments of PG&E Regarding Proposed Residential Clothes Washer Water Factor Standards* (Docket No. 03-AAER-01) (RCW) November 11, 2003, p. 11. Comments were prepared for PG&E by Energy Solutions.

62 Gleick, et al.

63 Gleick et al., p. 63.

64 Gleick, et al., p.2.

65 Vickers, p.232.

66 Benedykt Dziegielewski, et al., *Commercial and Insitutional End Uses of Water* (Denver, CO: American Water Works Association Research Foundation, 2000).

67 Gleick, et al., p.2.

68 For additional descriptions of CII water conservation measures, see Vickers; Gleick, et.al.; and Miriam Pye, *Making Business Sense of Energy Efficiency and Pollution Prevention* (Washington, DC: American Council for an Energy Efficient Economy, 1998).

69 Vickers, p.235.

70 Gleick, et.al., p.83.

71 Ibid. p.91.

72 "Conservation Tips," Sacramento Municipal Utility District, available at: www.smud.org/residential/saving/conservation.html.

73 Department of Water Resources, *California Water Plan Update: Bulletin 160-98*.

74 Anderson, p.6. This latter figure includes energy used in food processing such as water sterilization, pumping, reclamation for washing, and other purposes.

75 California Energy Commission, p.1.

76 The Department of Water Resources does not have a good estimate of agricultural water use efficiency. While the CALFED water use efficiency program plan estimates average statewide water use efficiency as 73 percent, there is good reason to doubt this estimate. The estimate is based on data from the Westlands Water District during a limited number of irrigation seasons—a very limited and nonrepresentative sample. For additional discussion of agricultural water conservation, see Vickers; Ronnie Cohen and Jennifer Curtis, *Agricultural Solutions: Improving Water Quality in California Through Water Conservation and Pesticide Reduction* (New York: NRDC, 1998); Elise Fulstone, *The Role of Improved Irrigation Technologies in Helping Farmers Meet Environmental and Economic Challenges* (Washington, DC: Environmental and Energy Study Institute, 1997); and Department of Water Resources, *Agricultural Efficient Water Management Practices that Stretch California's Water Supply* (Sacramento, CA: 1995).

77 California Energy Commission, p. 5.

78 Anderson, p. 9.

79 Table 8 is modified from Burton.

80 Edward R. Osann and John E. Young, *Saving Water, Saving Dollars: Efficient Plumbing Products and the Protection of America's Waters* (Washington, DC: Potomac Resources, 1998), p. 10. Capital cost savings from reductions in wastewater flows will vary tremendously by location, particularly for older systems designed for certain flows. For new systems, however, water conservation and reduced wastewater flows should translate more reliably into reduction in wastewater capital costs.

81 To create this spreadsheet, we modified and expanded the methodology of Wilkinson (2000) to determine the energy embedded in water use from source to disposal.

82 The residential, commercial/industrial/institutional (CII), and agricultural percentages of total use in the table are from San Diego County Water Authority staff for the year 2010. They were disaggregated using data from the Awwa Research Foundation (1999) and Gleick (2003).

83 U.S. Census Bureau, Census 2000 figures available at: www.census.gov.

84 California Energy Commission, "Chula Vista Power Project, Chula Vista, Emergency Peaker Project," Energy Commission Docket Number: 01-EP-3. Available at: www.energy.ca.gov/sitingcases/peakers/chulavista/.

85 For more information about the environmental implications of drainage water and conflicts over responsibility for management and disposal of drainage flows, see, for example, *Management Plan for Agricultural Subsurface Drainage and Related Problems on the Westside San Jaoquin Valley*, (Sacramento, CA: U.S. Department of Interior and California Resources Agency, 1990).

86 The district is within the Tulare Lake groundwater basin, and Westside and Pleasant Valley subbasins. Historic groundwater depth maps are available from the Westlands Water District at: www.westlandswater.org/maps/dgwmapsel.htm and the Department of Water Resources online database, available at: http://wdl.water.ca.gov.

87 Russ Freeman, Resources Division, the Westlands Water District, personal communication, June 2003.

88 The original district included approximately 376,000 acres. It is currently referred to as Priority Area I (PAI). Most of PAI is east of the San Luis Canal and has gravity water service. Small recirculating pumps are used to pressurize supply laterals serving land adjacent to the San Luis Canal that is too high to be served through gravity laterals. The Westplains Water Storage District merged with Westlands in 1965, adding 210,00 acres. These lands are referred to as Priority Area II (PAII). Much of it is west and upslope of the San Luis Canal. It is served by pumping from the San Luis Canal and gravity supply from the Coalinga Canal. About one-third of the land between the San Luis Canal and the Coalinga Canal is served by pumping from the San Luis Canal. About 18,000 acres were added to the district subsequent to the Westplains merger. These lands are referred to as Priority Area III (PAIII). Unlike

PAI and PAII, PAIII does not have a water service contract. It receives surplus Central Valley Project water or hardship water when available from the bureau during drought periods to preserve trees and vines.

89 Barry Mortimeyer, chief, Central Valley Operations, U.S. Bureau of Reclamation, personal communication, June 2003.

90 The unit factors are for water moved at the point of energy use. Due to system losses, actual energy used per acre-foot of water delivered is higher, as discussed in Chapter 2. In this case study, conveyance losses were not included due to data limitations.

91 Barry Mortimeyer, chief, Central Valley Operations, U.S. Bureau of Reclamation, personal communication, May 2003.

92 Since water in the canals cannot be differentiated by recipient, just as electrons in power lines cannot be labeled "for customer A," it is unclear how the 90 kWh/af net consumption of storing water in San Luis should be allocated. Westlands Water District staff claim it should not be allocated to them (Russ Freeman, Resources Division, The Westlands Water District, personal communication, July 2003) because priority is given to deliveries to exchange contractors and wildlife refuges. But it is not clear how these priorities affect timing of deliveries or that it is appropriate to differentiate this energy by recipient. An equally valid approach would be to charge a percentage of 90 kWh/af to all recipients, where the percentage reflects the percentage of water passing the San Luis Reservoir outlet that is pumped into and then recovered from San Luis Reservoir.

93 The 245 kWh/af figure does not apply to every acre-foot of Central Valley Project water delivered in the district since the district lifted only about 400,000 af/yr, or about 50 percent of Central Valley Project deliveries, in 2002.

94 Pimental and cost and return studies prepared by the University of California Cooperative Extension, which are available at www.agecon.ucdavis.edu/outreach/crop/cost.htm.

95 We have not, for example, estimated the energy embedded in the materials used on farm. Pimental and Pimental provide such data for around a dozen examples, including some relatively old data on tomato production in California. In that example, gasoline and diesel fuel account for a little more than half of the embedded energy inputs. See D. Pimental, and M. Pimental, editors, *Food, Energy, and Society* (Niwot, Colorado: University of Colorado Press, 1996).

96 W. Illingworth, D. Mitchell, L. Dale, A. Fargeix, R. T. Mott, and S. Msangi, *Analysis of Economic Impacts of Proposed Land Retirement in Westlands Water District, Final Report* (Westlands Water District, May 2003).

97 Permanent retirement of up to 200,000 acres of land within the Westlands Water District has been proposed by the district itself. According to Illingworth, et.al., the Westlands Water District is developing plans to purchase and retire up to 100,000 acres of land within the district. The district would retain ownership of these lands and would redirect the water from these lands to non-drainage impaired land within the district. An additional 100,000 acres of land retirement may take place if an agreement is reached with the Department of the Interior.

98 100,000 acres times 2.34 acre-feet of water-use-per-acre times 435 kWh per acre-foot times 70 percent = 71 million kWh.

99 Russ Freeman, Resources Division, the Westlands Water District, personal communication, June 2003.

100 Wilkinson (2000) and Table 12 of this report.

101 W. Illingworth, D. et.al., May 2003.

102 Russ Freeman, Resources Division, the Westlands Water District, personal communication, August 2003.

103 *Pocket Guide: The Northwest Power Planning Council's Fast Facts about the Columbia River Basin*, (Portland, Oregon: Northwest Power and Conservation Council, 1992), p. 9.

104 Ibid.

105 The National Marine Fisheries Service's RPAs are "expected to cost $1 billion a year, significantly more than the $800 million estimated one-time cost of breaching the four dams," (*Chicago Tribune*, March 5, 2001).

106 Foundation for Water and Energy Education, "What Makes the Columbia River Basin Unique and How We Benefit," available at: www.fwee.org/c-basin.html.

107 The National Marine Fisheries Service Press Release NOAA 97-R136, "Federal Fishery Agency Calls for a No-Net-Loss Approach to New Irrigation Pumping in Columbia Basin," May 16, 1997. Available at: www.publicaffairs.noaa.gov/pr97/may97/noaa97-r136.html.

108 Bonneville Power Administration, "Aluminum Companies Chip In," *Journal of the Bonneville Power Administration*, February 2001, p.2.

109 Linda Mapes, "Abundant Idaho Water Tied Up Tight," *Seattle Times*, April 29, 2001.

110 Washington State Department of Ecology, *2001 Drought Response Report to the Legislature*, (Olympia, WA: 2001), p. 18.

111 Joel R. Hamilton and R. Garth Taylor, "The Idaho Power Irrigation Electricity Buyout," *Idaho Economics*, November 2001.

112 Michele DeHart, manager, Fish Passage Center, in a letter to Rich Zabel, National Marine Fisheries Service, commenting on the National Marine Fisheries Service draft report on survival estimates for spring-migrating juvenile salmonids through Snake and Columbia River dams and reservoirs during 2001, February 27, 2002.

113 "The [Federal Salmon Plan]'s flow and spill provisions were not met on even a single day during 2001," Save Our Wild Salmon, *Failing Salmon, Failing People*, (Seattle, 2001), Executive Summary.

114 Fish Passage Center *Annual Report* (Portland, OR: 2001), p. xix.

115 This estimate assumes that energy used to grow potatoes is an average for the project area. The assumption needs verifying, but it is useful for illustration purposes and is plausible based on cultivation and harvest energy estimates per acre-feet of water use developed in the Westlands case study.

116 Bonneville Power Administration, "Follow Up Questions for Power Net Revenue Improvements," *Sounding Board*, March 2004, p. 2.

117 The CALFED Bay-Delta Program Record of Decision indicates that the program will produce a "definition of appropriate measurement by the end of 2001," and that it will work "to develop legislation for introduction and enactment in the 2003 legislative session requiring the appropriate measurement of all water uses in the state of California," (record of decision, p. 63). CALFED has missed both of these dates.

118 The record of decision was adopted in August 2000 by state and federal water management agencies. The plan states that "CALFED agencies will support legislation that encourages groundwater management at the sub-basin level," (record of decision, p.47). We are not aware of progress toward the enactment of this legislation.

119 The record of decision states that "(By) the end of 2002, CALFED Agencies will implement a process for certification of water suppliers' compliance with the terms of the urban MOU, including implementation of best management practices for urban water conservations," (record of decision, p. 62). CALFED has missed this target.

120 Wilkinson.

121 This assumption is worthy of further research in some settings. Since both treated and untreated water are delivered to San Diego County in pipelines rather than canals, the assumption is probably valid in our case study. But it may not be valid in all settings since friction losses in pipelines often exceed those in open channels.

122 Robert C. Wilkinson, *Methodology for Analysis of the Energy Intensity of California's Water Systems, and an Assessment of Multiple Potential Benefits Through Integrated Water-Energy Efficiency Measures* (Santa Barbara, CA: University of California, Santa Barbara, Environmental Studies Program, 2000).

123 Wilkinson.

124 Robert Wilkinson, Professor, University of California Santa Barbara, personal communication, September 2003.

125 Terry Spragg, "Response to the Administrative Law Judge's Ruling Requiring Supplemental Information Granting Motion to Intervene" (Spragg & Associates, June 11, 1999).

126 William L. Kahrl, *California Water Atlas* (The State of California, 1979).

127 CH2Mhill, Final Environmental Impact Report/Environmental Impact Statement, Water Conservation and Transfer Project, Imperial Irrigation District, June 2002; Henrik Olstowski, superintendent of general power generation, Imperial Irrigation District, personal communication June 2003.

128 Jeff Stephenson, water resources specialist, San Diego County Water Authority, personal communication, June 2003.

129 Ibid.

130 Ibid.

131 Ibid.

132 Ibid.

133 Ibid.

134 Ibid.

135 Ibid.

136 Ibid.

137 Ibid.

138 Peter H. Gleick, D. Haasz, C. Henges-Jeck, V. Srinivasan, G. Wolff, and A. Mann, *Waste Not Want Not: The Potential for Urban Water Conservation in California* (Oakland: Pacific Institute, 2003).

139 Ibid.

140 "Energy Star Qualified Clotheswashers" list and "Energy Star Qualified Dishwashers" list, available at: www.energystar.gov/ia/products/prod_lists/clotheswash_prod_list.pdf and www.energystar.gov/ia/products/prod_lists/dishwash_prod_list.pdf, respectively.

141 Amy Vickers' *Handbook of Water Use and Conservation: Homes, Landscapes, Business, Industries, Farms* (Amherst, MA: WaterPlow Press, 2001).

142 United States Department of Energy, "How to Buy an Energy Efficient Water-Cooled Chiller," available at: www.eere.energy.gov/femp/procurement/wc_chillers.html.

143 City of San Jose Environmental Services Department, *Water Conservation Guide for Office Buildings and Commercial Establishments* (San Jose, California: City of San Jose, 1992).

144 Osman Sezgen and Jonathan G. Koomey, *Technology Data Characterizing Water Heating in Commercial Buildings: Application to End-Use Forecasting* (Berkeley, California: University of California Berkeley, Lawrence Berkeley National Laboratory, 1995).

145 A. Amarnath, *Maximizing Wastewater Reduction for Process Industries*, TR-1114205 (Palo Alto: Electric Power Research Institute, 1999).

146 Ibid.

147 U.S. Geological Survey, "Estimated Use of Water in the United States, 1990," in *USGS National Circular* 1081, available at: http://water.usgs.gov/watuse/wucircular2.html.

148 Jeff Stephenson, Water Resources Specialist, San Diego County Water Authority, personal communication, June, 2003.

# Attachment 22

Welcome to the California Energy Commission

WWW.ENERGY.CA.GOV / ELECTRICITY / US PER CAPITA ELECTRICITY 2005

## U.S. Per Capita Electricity Use By State In 2005

| Ranking Highest | State | Population (thousands) | kWh (millions) | kWh per capita |
|---|---|---|---|---|
| 1 | Wyoming | 509 | 14,138 | 27,787 |
| 2 | Kentucky | 4,173 | 89,351 | 21,414 |
| 3 | District of Columbia | 582 | 11,816 | 20,301 |
| 4 | Alabama | 4,548 | 89,202 | 19,612 |
| 5 | South Carolina | 4,247 | 81,254 | 19,132 |
| 6 | Tennessee | 5,956 | 103,905 | 17,446 |
| 7 | Louisiana | 4,507 | 77,389 | 17,170 |
| 8 | North Dakota | 635 | 10,840 | 17,081 |
| 9 | Indiana | 6,266 | 106,549 | 17,004 |
| 10 | Arkansas | 2,776 | 46,165 | 16,632 |
| 11 | West Virginia | 1,814 | 30,152 | 16,621 |
| 12 | Mississippi | 2,908 | 45,901 | 15,782 |
| 13 | Nebraska | 1,758 | 26,976 | 15,343 |
| 14 | Idaho | 1,429 | 21,853 | 15,288 |
| 15 | Oklahoma | 3,543 | 53,707 | 15,157 |
| 16 | North Carolina | 8,672 | 128,335 | 14,798 |
| 17 | Texas | 22,929 | 334,258 | 14,578 |
| 18 | Georgia | 9,133 | 132,265 | 14,483 |
| 19 | Montana | 935 | 13,479 | 14,420 |
| 20 | Delaware | 842 | 12,137 | 14,419 |
| 21 | Iowa | 2,966 | 42,757 | 14,418 |
| 22 | Virginia | 7,564 | 108,850 | 14,390 |
| 23 | Kansas | 2,748 | 39,024 | 14,200 |
| 24 | Ohio | 11,471 | 160,176 | 13,964 |
| 25 | Missouri | 5,798 | 80,940 | 13,961 |
| 26 | Nevada | 2,412 | 32,501 | 13,473 |
| 27 | Washington | 6,292 | 83,425 | 13,259 |
| 28 | Minnesota | 5,127 | 66,019 | 12,877 |
| 29 | Oregon | 3,639 | 46,419 | 12,756 |
| 30 | Wisconsin | 5,528 | 70,336 | 12,724 |
| 31 | Florida | 17,768 | 224,977 | 12,662 |
| 32 | South Dakota | 775 | 9,811 | 12,661 |
| | United States | 296,507 | 3,660,969 | 12,347 |

| | | | | |
|---|---|---|---|---|
| 33 | Maryland | 5,590 | 68,365 | 12,231 |
| 34 | Pennsylvania | 12,405 | 148,273 | 11,952 |
| 35 | Arizona | 5,953 | 69,391 | 11,656 |
| 36 | Illinois | 12,765 | 144,986 | 11,358 |
| 37 | Michigan | 10,101 | 110,445 | 10,934 |
| 38 | New Mexico | 1,926 | 20,639 | 10,716 |
| 39 | Colorado | 4,663 | 48,353 | 10,369 |
| 40 | Utah | 2,490 | 25,000 | 10,039 |
| 41 | Connecticut | 3,501 | 33,095 | 9,454 |
| 42 | Vermont | 622 | 5,883 | 9,452 |
| 43 | New Jersey | 8,703 | 81,897 | 9,410 |
| 44 | Maine | 1,318 | 12,363 | 9,378 |
| 45 | Alaska | 663 | 5,913 | 8,915 |
| 46 | Massachusetts | 6,433 | 57,228 | 8,895 |
| 47 | New Hampshire | 1,307 | 11,245 | 8,605 |
| 48 | Hawaii | 1,273 | 10,539 | 8,277 |
| 49 | New York | 19,316 | 150,148 | 7,773 |
| 50 | Rhode Island | 1,074 | 8,049 | 7,497 |
| 51 | California | 36,154 | 254,250 | 7,032 |

Sources:
Population -
http://www.census.gov/popest/states/tables/NST-EST2006-01.xls
Kilowatt-hour -
http://www.eia.doe.gov/cneaf/electricity/epa/sales_state.xls

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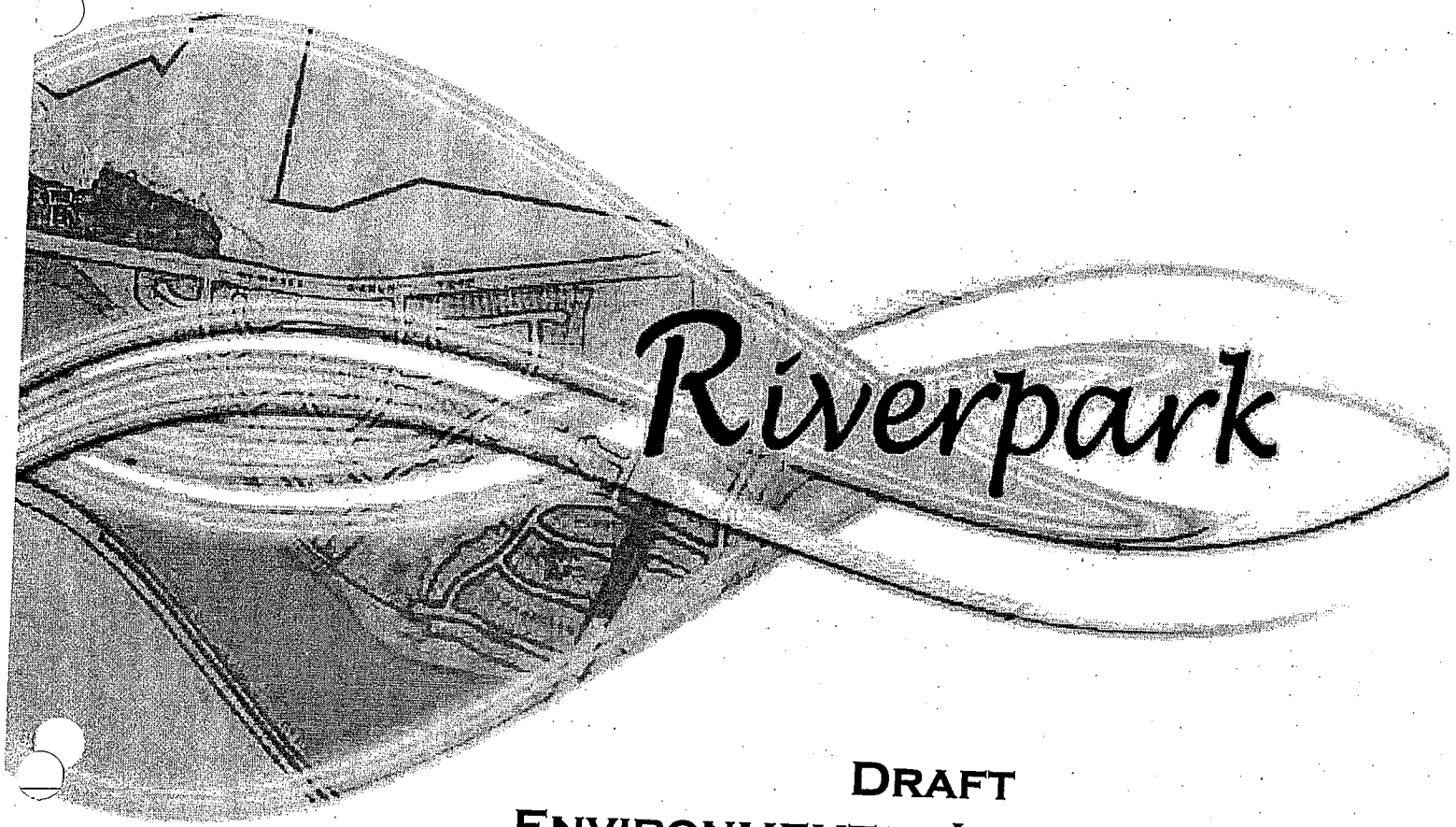
# Attachment 23-A




# DRAFT
# ENVIRONMENTAL IMPACT REPORT

SCH No. 2002091081

## VOLUME I

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Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

**Table ES-1**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES** | | | |
| Much of the elevated portion of the project site is underlain by accumulations of ancient river channel deposits that were deposited on a series of successively lower benches cut in the underlying Saugus Formation bedrock by the ancestral Santa Clara River. These depositional Terrace Deposits exhibit crude horizontal stratification. Quaternary Alluvium covers the valley floors. | **a.** | **General** | |
| | 4.1-1 | All project site development shall be performed according to the recommendations identified in Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003, and in Geologic and Geotechnical Report – Addendum No. 1 Revised Tentative Tract Map (Revised June 11, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated June 30, 2003. | Not Significant |
| | 4.1-2 | Mitigation measures for geotechnical resources shall be implemented so as not to conflict with mitigation measures as section forth in **Section 4.6, Biological Resources**, of this EIR. | |
| | **b.** | **Earth Materials** | |
| | 4.1-3 | All grading shall be accomplished under the observation and testing of the Project Soils Engineer, Engineering Geologist and/or their authorized representatives in accordance with the recommendations contained herein, the current Unified Building Code requirements and "Recommended Earthwork Specifications" as presented in Appendix E of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003. | |
| | 4.1-4 | During site preparation, the site shall be cleared and stripped of organics (vegetation), topsoil, roots, undocumented artificial fill, rubble, construction debris and other unsuitable materials, as applicable, and the site shall be graded to provide a firm base for compacted fill. All organics shall be removed from the site for proper disposal. The Geotechnical Engineer and/or his representatives shall observe the excavated areas prior to placing compacted fill. | |
| | 4.1-5 | In order to provide a uniform firm bottom prior to placing fill, all unconsolidated Alluvium, slopewash, colluvial soils and severely weathered Terrace Deposits and bedrock shall be removed from areas to receive fill. The estimated depths of removals (excluding landslides) are 5 to 23 feet as shown on **Figure 4.1-1**. The exact depth and extent of necessary removals will be determined in the field during the grading operations when observations and more location-specific evaluations can be performed. | |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-6 All existing artificial fill (af) shall be removed and replaced with compacted fill. Removals at the locations of exploratory trenches shall be extended to the bottom of the trench backfill if the adjacent removal depths are shallower than the trench. | |
| | 4.1-7 In areas to receive compacted fill where the surface gradient is steeper than 5:1 (h:v), the soil mantle, colluvium and unsuitable material shall be removed and such areas benched horizontally into competent material prior to or in conjunction with fill placement (See Appendix E, Fill Over Natural Slope, Figure E2 of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003). | |
| | 4.1-8 After the ground surface to receive fill has been exposed, it shall be ripped to a minimum depth of 6 inches, brought to optimum moisture content or above, thoroughly mixed to obtain a near uniform moisture condition and uniform blend of materials, and then compacted to the required relative compaction per the latest ASTM D 1557 laboratory maximum density. | |
| | 4.1-9 Where recommended removals encounter ground water, water levels shall be controlled by providing an adequate excavation bottom slope and sumps for pumping water out as the excavation proceeds, or ground water may be lowered by installing shallow dewatering well points prior to grading. Partial removals of soils above the water table and soil improvement below the water table (e.g., shallow compaction grouting) may be another option. The determination as to which measures are to be used shall be made by the project Civil Engineer. Dewatering may be needed depending on the season when the removals are performed. All discharges from dewatering operations, if any, shall comply with the National Pollutant Discharge Elimination System permit requirements of project construction. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-10 A minimum 5-foot thick over-excavation shall be performed on all cut-lots, transitional lots (transitions between bedrock, fill, Terrace Deposits and Alluvium), and streets. This over-excavation will provide attenuation of potential differential settlements or differential material response to seismic events and provide a uniform base for structural support of buildings. If the maximum depth of fill exceeds 15 feet on a cut/fill transition lot, then the thickness of the fill cap shall be one-third of the deepest fill thickness below any proposed structure (See Appendix E, Cut Lot and Cut Fill Lot (Transitional), Figure E3, of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003). If excavation of the native soils (i.e., bedrock) exposes expansive materials, then the lot over-excavation shall be deepened to 8 feet. | |
| | 4.1-11 On-site soils that are free of debris, over-size rocks, topsoil, and organic matter may be used as sources for compacted fills. Rock or similar irreducible material with a maximum dimension greater than 8 inches may not be placed in the fill. Rocks or hard fragments larger than 4 inches shall not compose more than 25 percent of the fill and/or lift. Any large rock fragments over 8 inches in size, may be incorporated into the fill as rockfill in windrows after being reduced to the specific maximum rock fill size (See Figure E4, Rock Disposal, in Appendix E of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003). Where fill depths are too shallow to allow large rock disposal, special handling, or removal may be required depending upon on-site field decisions made during grading operations by the project Geologist/Geotechnical Consultant (See "Recommended Earthwork Specifications," Appendix E of the Seward report.) | |
| | 4.1-12 All fill material shall be placed in uniform lifts not exceeding 8 inches in its loose state and compacted to a minimum of 90 percent relative compaction as determined based on the latest ASTM Test Designation D-1557. Additional field compaction requirements are presented in Appendix E, "Recommended Earthwork Specifications" of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003. Appendix E also includes recommended specifications for placement of trench backfill. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-13 For fills deeper than 40 feet, the portion of fill below 40 feet depth shall be compacted to a minimum of 93 percent relative compaction. These areas shall be delineated at the Grading Plan stage. | |
| | 4.1-14 Fill slope inclination shall not be steeper than 2:1 (h:v). The fill material within approximately one equipment width (typically 15 feet) of the slope face shall be constructed with cohesive material obtained from on-site soils. The finished fill-slope face shall be constructed by over-building the slope and cutting back to the compacted fill material. Stability Fills are recommended where cut-slope faces will expose fill-over bedrock, Alluvium-over-bedrock or Quaternary Terrace Deposits over bedrock conditions. These fills shall be constructed with a keyway at the toe of the fill slope with a minimum equipment width, but not less than 15 feet, and a minimum depth of 3 feet into the firm undisturbed earth. Following completion of the keyway excavations, the Project Engineering Geologist shall observe and approve the keyway bottom prior to backfilling with certified engineered fill. | |
| | 4.1-15 Where fill slopes are constructed above natural ground with a gradient of 5:1 (h:v) or steeper, all topsoil, colluvium, and unsuitable material shall be removed and a keyway shall be constructed at the toe of the fill slope with a minimum width of 15 feet, and a minimum depth of 3 feet into firm undisturbed earth (See Appendix E, Fill Slope Over Natural Slope diagram, Figure E5 of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003). Following completion of the keyway excavations, the project Engineering Geologist/Geotechnical Engineer or designated representative shall observe and approve the keyway bottom prior to backfilling with compacted fill. | |
| | 4.1-16 Where fill slopes toe out on relatively level natural ground, the removals shall be performed to a minimum 1:1 projection from the toe of slope to the recommended removal depth, (See Appendix E, Fill Slope Toeing Out on Flat Alluviated Canyon, Figure E6 of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003). | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-17 Where sliver fill-slopes are proposed, the slope shall be constructed with a minimum 15-foot width Stability Fill throughout, which is keyed in at the toe of slope (See Appendix E, Stability/Buttress Fill and Backdrains Detail, Figure E7 of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003). | |
| | 4.1-18 Fourteen landslides are located within or in the vicinity of the proposed development area of the project. These landslides shall be mitigated as recommended in Table 1 of Geologic and Geotechnical Report – Addendum No. 1 Revised Tentative Tract Map (Revised June 11, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated June 30, 2003. | |
| | 4.1-19 Nineteen proposed cut-slopes that would be 25± feet or higher have been identified on the subject site and are designated them as CS-1 through CS-19. Recommended mitigation, if necessary, for each slope as presented in Cut-Slope Summary (Table 2 of Geologic and Geotechnical Report – Addendum No. 1 Revised Tentative Tract Map (Revised June 11, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated June 30, 2003 shall be followed. This determination shall be made by the Geologist/Geotechnical Consultant prior to grading activities. It has been conservatively assumed for the purposes of stability analysis that weak bedding planes may occur anywhere in the proposed cut-slopes. If any of the smaller proposed cut-slopes (less than 25± feet in height) have adverse geologic grading configurations (fill over cut), they shall be mitigated, if necessary, with a standard 15- to 20-foot wide key (depending on the proposed cut-slope height) and benching similar to a Stability Fill. A "Typical Fill above Cut-Slope" detail is shown on Figure E8 within Appendix E of the Seward report. This determination shall be made by the project Geologist/Geotechnical Consultant prior to grading activities. | |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-20 All permanent cut-slopes shall be constructed at a slope ratio not steeper than 2:1 (horizontal to vertical). All permanent cut-slopes exposing Terrace Deposits or Alluvium shall be constructed as a stability fill. Temporary cut slopes in competent rock may be constructed as steep as 1.5:1 (h:v). Potential unstable subsurface conditions exposed during construction, such as adverse bedding, joint planes, zones of weakness or exposed seepage, may require either flatter slopes than specified above or construction of benches. An Engineering Geologist shall observe all backcuts during the grading operations and provide appropriate recommendations, if necessary. | |
| | 4.1-21 For the south and southwest facing natural ridge slope located above Planned Area D in the vicinity of Lot No. 526, groundwater levels shall be permanently limited to those found to be necessary for stability of the affected slopes through surface water control as specified in **Mitigation Measures 4.1-27** through **4.1-30.** No piped water shall be allowed above elevation 1,250 feet above msl on the existing natural ridge north and northeast of Lot No. 526, and the area of the existing natural ridge above elevation 1,250 feet above msl shall be recorded as a Restricted Use Area (RUA) on the Final Map. The RUA does not allow for structures and is intended to provide gross stability above the development in order to satisfy the City of Santa Clarita slope stability requirements. This recommended RUA is hatch marked on **Figure 4.1-1.** See the slope stability analysis in Appendix F of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003 for details. | |
| | 4.1-22 Proposed cut-slope CS-10 shall be constructed as a stability fill due to Quaternary Terrace Deposits anticipated to be exposed within the proposed slope face. A 20-foot building setback shall be constructed from the top of proposed cut-slope CS-10 for Lot Nos. 386 through 391 due to the steep gradient of the natural slope located below the proposed cut slope. This setback is based on geologic/geotechnical judgment and shall be designated on the Final Map as a Restricted Use Area; the setback line is hatch marked on **Figure 4.1-1.** The RUA does not allow for structures and is intended to provide gross stability above the development in order to satisfy the City of Santa Clarita slope stability requirements. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-23 The recommended building setback from the top of proposed cut-slope CS-10 at the rear of Lot Nos. 386 through 391 located on **Figure 4.1-1** shall be delineated on the Final Map as a Restricted Use Area. The RUA does not allow for structures and is intended to provide gross stability above the development in order to satisfy the City of Santa Clarita slope stability requirements. The RUA determination is made by the Geologist/Geotechnical Consultant and is made prior to recordation of the Final Map. The standard setbacks from ascending and descending slopes provided in the California Code/Unified Building Code shall be followed, unless superseded by specific geologic and/or soils engineering evaluations. | |
| | 4.1-24 All of the exploratory trenches and borings previously excavated for this project shall be over-excavated and backfilled with compacted fill in accordance with the earthworks recommendations of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003. | |
| | **c. Drainage Control** | |
| | 4.1-25 Whenever groundwater seepage is observed, the condition shall be evaluated by the Engineering Geologist and Geotechnical Engineer prior to covering with fill material. | |
| | 4.1-26 Surface drainage control design shall include provisions for positive surface gradients to ensure that surface runoff is not permitted to pond, particularly above slopes or adjacent to building foundations or slabs. Surface runoff shall be directed away from slopes and foundations and collected in lined ditches or drainage swales via non-erodible drainage devices, which shall discharge to paved roadways or existing watercourses. If these facilities discharge onto natural ground, means shall be provided, as directed by the project Civil Engineer, to control erosion and to create sheet flow. | |
| | 4.1-27 Site grading shall be inspected, particularly after heavy, prolonged rainfall, by the City of Santa Clarita to identify erosion areas at an early stage. Maintenance work shall be done as soon as practical to repair these areas and prevent their enlargement. | |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-28 Planting and irrigation standards within the City of Santa Clarita Grading Code shall be adhered to in order to prevent soil erosion. | |
| | 4.1-29 Fill slopes and stability fills, as applicable, shall be provided with subsurface drainage as necessary for stability as determined by the project Geologist/Geotechnical Consultant. A typical backdrain detail is shown on Figure E7, Appendix E of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003. Also, subdrains along the bottom of canyon fills shall be constructed. A typical canyon subdrain detail is presented on Figure E9 of the Seward report. The existing subdrains constructed during the grading for the Rio Vista water treatment facility shall be extended to daylight out of the future planned grading or connected to the future storm drains. | |
| | 4.1-30 All final grades shall be sloped away from the building foundations to allow rapid removal of surface water runoff. No ponding of water shall be allowed adjacent to the foundations. Plants and other landscaped vegetation requiring excessive watering shall be avoided adjacent to the building foundations. Should landscaping be constructed, an effective water-tight barrier shall be provided to prevent water from affecting the building foundations. | |
| | **d. Shrinkage, Bulking, and Subsidence** | |
| | 4.1-31 The Project Engineer shall design pad grades with sufficient flexibility to accommodate a possible shortage of fill of up to 10 percent of the total yardage graded due to potential shrinkage of fill and potential subsidence due to dewatering. | |
| | **e. Foundation and Settlement Considerations** | |
| | 4.1-32 The structural design shall include seismic geotechnical parameters in accordance with UBC requirements for Seismic Zone 4. These parameters will be provided at the Grading Plan stage. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-33 Shallow spread footings for foundation support of residential structures can adequately be placed on compacted engineered fill as stated in **Mitigation Measures 4.1-12** and **4.1-13**. Support for heavier structures, if applicable, shall be addressed at the Grading Plan stage. Minimum specifications for continuous (wall) foundation dimensions are 12 inches wide and 12 inches deep below lowest adjacent grade for single-story residential structures. Tentatively, an allowable bearing capacity of 1,800 pounds per square-foot can be used for (minimum-sized) shallow foundations constructed in certified compacted fill. This tentative allowable bearing value shall be confirmed by further field and laboratory testing by the Project Geologist of the site soils before use in design plans. Lateral resistance of footing walls shall be provided at the Grading Plan stage. | |
| | 4.1-34 If, during grading operations, the resulting cut-fill transition is steep, as determined by the project Geologist/Geotechnical Consultant, at depth below the building area, the geometry of the transition shall be reviewed during grading operations by the Soils Engineer on a site specific basis to evaluate the need for additional over excavation removals and/or additional foundation reinforcement. As a general guideline, steep cut/fill transitions would include slope gradients steeper than 4:1 (h:v) and overall variations in fill thickness of greater than 15 feet that occur within 20 feet of final pad grade. The determination of need for over excavation of materials shall be guided by Figure E3 (Appendix E), "Cut Lot (Transitional)" and "Cut-Fill Lot (Transitional") of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003, which provides a foundation grading detail for locations where foundations will straddle transition zones between cut and fill materials. | |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-35 To minimize significant settlements, the upper soils in areas to receive fills shall be removed and replaced with compacted fill. Some minor settlements will be expected due to loads from high fills (e.g., higher than 30 feet). Currently, locations of proposed high fills are: CPT-6, CPT-7, CPT-8, CPT-10, CPT-11, CPT-12, CPT-14, CPT-17, CPT-19, CPT-32 and CPT-33. Most of the settlements due to the load of added fill will occur during and shortly after rough grading is complete. However, since lenses of relatively compressible clayey soils exist below recommended removal depths, some of the fill settlements will not occur until the ground water table is lowered below the compressible clay lenses. Ground water table lowering is usually the result of pumping from water wells. (Note: the project would not directly withdraw groundwater.) Alternatively, the site may be temporarily surcharged with earth fill sufficient to simulate the load increase on the compressible clay lenses due to lowering of the ground water table, as determined by the project Geologist/Geotechnical Consultant. | |
| | 4.1-36 At other alluvial removal areas, potential settlements in Alluvium shall be minimized by the removals and recompaction recommended in Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003. Also, potential effects from localized seismically-induced settlements will be attenuated by the recompacted upper layers and proposed additional fills (See of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003). | |
| | **f. Excavations, Shoring and Backfill Recommendations** | |
| | 4.1-37 Excavations deeper than 3 feet shall conform to safety requirements for excavations as set forth in the State Construction Safety Orders enforced by the State Division of Industrial Safety, CAL OSHA. Temporary excavations 12 feet or lower shall be no steeper than 1:1 (h:v). For excavations to 20 feet in height, the bottom 3.5 feet may be vertical and the upper portion between 3.5 and 20 feet shall be no steeper than 1.5:1 (h:v). Excavations not complying with these requirements shall be shored. The project Geologist/Geotechnical Consultant shall determine at the time of field inspection if excavation walls in sands and dry soils shall be kept moist, but not saturated at all times. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.1 GEOTECHNICAL RESOURCES (continued)** | | |
| | 4.1-38 Parameters for design of cantilever and braced shoring shall be provided at the Grading Plan stage. | |
| | 4.1-39 The bases of excavations or trenches shall be firm and unyielding prior to foundations or utility construction. On-site materials other than topsoil or soils with roots or deleterious materials may be used for backfilling excavations. Densification (compaction) by jetting may be used for on site clean sands or imported equivalent of coarser sand provided they have a Sand Equivalent greater than or equal to 30 as determined by ASTM D2419 test method. Specifications for placement of trench backfill shall be adhered to and are presented in Appendix E of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003. | |
| | **g. Expansive Soils Considerations** | |
| | 4.1-40 The measures presented in Table E1, Minimum Foundation and Slab Recommendations for Expansive Soils, in Appendix E of Geologic and Geotechnical Report; Review of Tentative Tract Map, (Dated February 25, 2003), prepared by Allan E. Seward Engineering Geology, Inc., and dated April 4, 2003, shall be implemented to minimize the effects of soil expansion potential. It is anticipated that compacted fill from the on-site materials will have a very low to medium expansion potential. The expansion potential of the site soils exposed at rough grade shall be tested again after site grading is complete and the final foundation design shall be based on those expansion test results. | |
| | **h. Corrosivity and Chemical Attack Considerations** | |
| | 4.1-41 On-site soils classify as severely corrosive to corrosive to buried metals per County of Los Angeles classification. Pending additional testing, either Type I or II cement may be considered for use in concrete placed in contact with the ground. Mitigating measures for soil corrosivity shall be finalized by the Project Engineer based on additional confirmatory tests that shall be performed at the Grading Plan stage. Final recommendations for concrete shall be in accordance with the latest UBC requirements, and a corrosion specialist shall provide mitigating recommendations for potential corrosion of metals in contact with on-site soils prior to issuance of a Grading Permit. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.2 FLOOD** | | | |
| The project site is located within an unnamed approximately 835-acre tributary watershed of the 1,624 square mile Santa Clara River basin. The Santa Clara River traverses the southern portion of the site. | **a.** | **Mitigation Measures Already Incorporated into the Project** | Not Significant |
| Site clearing and grading operations have the potential to discharge sediment downstream during storm events. Temporary erosion control measures in disturbed areas of the site during the construction phase of the project are proposed to reduce this potential impact to less than significant. Once developed consistently with the proposed Drainage Concept, the Riverpark project would reduce post-development storm water flows from the approximately 835-acre tributary watershed compared to existing conditions during a 50-year Capital Storm event. Specifically, the amount of burned and bulked runoff from the watershed would decrease from 2,225 cubic feet per second (cfs) to 2,1121 cfs, while the amount of debris volume would be reduced from 31,770 cubic yards (cy) to 15,558 cy. This 51 percent reduction in debris volume would be due to upstream debris basins proposed within the site and to the reduction in erosive areas on the site that contribute sediment and debris to the runoff. Implementation of the proposed Drainage Concept would meet the flood control requirements of the City of Santa Clarita and the Flood Control and Watershed Management Divisions of the Los Angeles County Department of Public Works and would reduce impacts to less than significant. | 4.2-1 | The on-site storm drains (pipes and reinforced concrete boxes) and open channels shall be designed and constructed for either the 25-year or 50-year Capital Storm. | |
| | 4.2-2 | Debris basins shall be constructed pursuant to Los Angeles County Department of Public Works requirements to intercept flows from undeveloped areas entering into the developed portions of the site. | |
| | 4.2-3 | Energy dissipaters consisting of either rip-rap or larger standard impact type energy dissipaters shall be installed as required by LACDPW at outlet locations to reduce velocities of runoff into the channel where necessary to prevent erosion. | |
| | 4.2-4 | Approximately 6,000 linear feet of buried bank stabilization shall be constructed along the Santa Clara River for residential, park and commercial project development (not including approximately 1,500 feet of toe protection [e.g. A-Jacks™, soil cement or equivalent]), and approximately 3,000 linear feet to allow for the construction of Newhall Ranch Road. Additionally, bridge abutments and piers shall be constructed for the Newhall Ranch Road/Golden Valley Road Bridge. | |
| There would be no appreciable increases in eroded areas of the riverbed due to buildout of the study area during the 2- 5- and 10-year storm events, and there would be a decrease in eroded areas during the 20-year and greater storm events. Therefore no significant stream erosion and debris deposition impacts are anticipated due to the project. | | | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.2 FLOOD (continued)** | | |
| | 4.2-5 The project shall comply with applicable mitigation measures of the Natural River Management Plan. | |
| | 4.2-6 The project is required to comply with the RWQCBLAR Municipal Permit (General MS4 Permit) Order No. 01-182, NPDES No. CAS004001 (adopted December 13, 2001), and with the State's General Construction Activity Storm Water Permit, California State Water Resources Control Board Order No. 99-08-DWQ, National Pollutant Discharge Elimination System (NPDES) No. CAS000002, reissued on April 17, 1997, as amended. | |
| | **b. Mitigation for Construction Impacts** | |
| | 4.2-7 All on- and off-site flood control improvements necessary to serve the project are to be constructed to the satisfaction of the City of Santa Clarita and/or County of Los Angeles Department of Public Works Flood Control Division. | |
| | 4.2-8 Prior to start of soil-disturbing activities at the site, a Notice of Intent (NOI) and Storm Water Pollution Prevention Plan (SWPPP) shall be prepared in accordance with and in order to partially fulfill the California State Water Resources Control Board Order No. 99-08-DWQ, NPDES General Permit No. CAS000002 (General Construction Permit). The SWPPP shall meet the applicable provisions of Sections 301 and 402 of the CWA by requiring controls of pollutant discharges that utilize best available technology economically achievable (BAT) and best conventional pollutant control technology (BCT) to reduce pollutants. The SWPPP shall be certified the City of Santa Clarita in accordance with the signatory requirements of the General Construction Permit and implemented concurrently with commencement of the soil-disturbing activity. | |
| | 4.2-9 Per the April 26, 2001 modification to the General Construction Permit, a contingency "Sampling and Analysis Plan" shall be developed in the event that the BMPs implemented at the construction site fail to prevent non-visible pollutants from discharging from the site. BMPs shall be inspected prior to storm events, every 24 hours during extended events, and after the storm events to ensure proper function of the BMPs and to identify necessary repairs in a timely manner. A record of the inspections and repairs shall be documented in the SWPPP. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.2 FLOOD (continued)** | | |
| | 4.2-10 Following the completion of the construction project and when the site has been stabilized, a Notice of Termination shall be filed with the RWQCBLAR. | |
| | 4.2-11 During all construction phases, temporary erosion control to retain soil and sediment on the site shall be implemented, including:<br>• re-vegetating exposed areas as quickly as possible;<br>• minimizing disturbed areas;<br>• diverting runoff from downstream drainages with earth dikes, temporary drains, slope drains, etc.;<br>• velocity reduction through outlet protection, check dams, and slope roughening/terracing;<br>• dust control measures, such as sand fences, watering, etc.;<br>• stabilizing all disturbed areas with blankets, reinforced channel liners, soil cement, fiber matrices, geotextiles, and/or other erosion resistant soil coverings or treatments;<br>• stabilizing the construction entrance/exist with aggregate underdrain with filter cloth or other comparable method;<br>• placing sediment control BMPs at appropriate locations along the site perimeter and at all operational internal inlets to the storm drain system at all times during the rainy season (sediment control BMPs may include filtration devices and barriers, such as fiber rolls, silt fence, straw bale barriers, and gravel inlet filters, and/or with settling devices, such as sediment traps or basins; and/or<br>• eliminating or reducing, to the extent feasible, non-storm water discharges (e.g., pipe flushing, and fire hydrant flushing, over-watering during dust control, vehicle and equipment wash down) from the construction site through the use of appropriate sediment control BMPs. | |
| | 4.2-12 All necessary permits, agreements, letters of exemption, or a Verification Request Letter from the ACOE and/or the CDFG for project-related development are to be obtained prior to issuance of grading permits. | |
| | 4.2-13 By October 1st of each year, a separate erosion control plan for construction activities shall be submitted to the local municipality describing the erosion control measures that will be implemented during the rainy season (October 1 through April 15). | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.2 FLOOD (continued)** | | |
| | **c. Mitigation Measures for Operational Impacts** | |
| | 4.2-14 A final developed condition hydrology analysis shall be prepared in conjunction with final project design when precise engineering occurs. This final analysis will be done to confirm that the final project design is consistent with this analysis. Those final calculations shall establish design features for the project that satisfy the criterion that post-development peak storm water runoff discharge rates, velocities, and duration in natural drainage systems mimic pre-development conditions. All elements of the storm drain system shall conform to the policies and standards of the Los Angeles County Department of Public Works, Flood Control Division, as applicable. | |
| | 4.2-15 Ultimate project hydrology and debris production calculations shall be prepared by a project engineer to verify the requirements for debris basins and/or desilting inlets. | |
| | 4.2-16 To reduce debris being discharged from the site, debris basins shall be designed and constructed pursuant to LACDPW Flood Control to intercept flows from undeveloped areas entering into the developed portions of the site. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.3 TRAFFIC/ACCESS** | | | |
| At buildout, the proposed project development would generate 13,300 average daily trips. | **a.** | **On-Site Mitigation Measures** | |
| The Riverpark project is located within the Bouquet Canyon Bridge and Thoroughfare District (Bouquet B&T District). This district is considered a full-mitigation district, that is, traffic improvements identified in the district mitigate traffic impacts created by planned growth within the district. In summary, the District has been designed to accommodate the needs of future development anticipated by the City and County General Plans. | 4.3-1 | The project applicant shall construct all on-site local roadways and intersections to City of Santa Clarita standards. | Significant |
| Mitigation in the form of securing right-of-way for roadways improvements is proposed for four intersections and are considered currently infeasible: | 4.3-2 | Two future major arterial roadways pass through the project site (Newhall Ranch Road and Santa Clarita Parkway) and are identified as traffic improvements in the Bouquet Bridge and Thoroughfare District. The project shall construct the portions of these arterials that are located within the site boundary to accommodate the project generated traffic; that is a total of two vehicular lanes (one in each direction) on both Newhall Ranch Road and Santa Clarita Parkway. Santa Clarita Parkway shall be extended from its intersection with Newhall Ranch Road, south approximately 1,500 linear feet. | |
| Pre-Interim Year (Occupancy of up to 500 units, without Newhall Ranch Road/Golden Valley Road Bridge)<br>• Valencia Boulevard/Magic Mountain Parkway | | The applicant can occupy up to 500 units with the construction of an extension of Newhall Ranch Road easterly to the furthest access point needed for the 500 units. This extension of Newhall Ranch Road for the occupancy of 500 units shall include a total of two vehicular lanes (one in each direction). | |
| Interim Year (Full-Buildout of Project)<br>• Valencia Boulevard/Magic Mountain Parkway<br>• Bouquet Canyon Road/Soledad Canyon Road<br>• Seco Canyon Road/Bouquet Canyon Road<br>• Whites Canyon Road/Soledad Canyon Road | | Prior to occupancy of the 501st unit, Newhall Ranch Road from Bouquet Canyon Road to the Soledad Canyon Road "flyover," including the Newhall Ranch Road/Golden Valley Bridge, shall be constructed and operational with a total of two vehicular lanes (one in each direction). | |
| | **b.** | **Off-Site Mitigation Measures** | |
| | | **Pre-Interim Year** | |
| | 4.3-3 | Valencia Boulevard & Magic Mountain Parkway: Add 3rd Eastbound Through Lane (requires right-of-way on south side of Valencia Boulevard, presently infeasible). | |
| | 4.3-4 | Bouquet Canyon Road & Soledad Canyon Road: Temporary configuration to consist of 3 Southbound Left-Turn Lanes and 2 Southbound Through Lanes. Would revert to 2 Southbound Left-Turn Lanes and 3 Southbound Through Lanes (existing configuration) when Cross-Valley Connector is completed. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.3 TRAFFIC/ACCESS (continued)** | | |
| | 4.3-5 Seco Canyon Road & Bouquet Canyon Road: Convert 1st Southbound Right-Turn Lane to a shared Left-Turn/Right-Turn Lane (for 1 Left-Turn Lane, 1 shared Left-Turn/Right-Turn Lane, 1 Right-Turn Lane).<br><br>The improvements at the Bouquet Canyon Road/Soledad Canyon Road intersection consist of reconfiguring the southbound approach to include three left-turn lanes and two through lanes. | |
| | 4.3-6 Bouquet Canyon Road/Newhall Ranch Road: Add 2nd Southbound Left-Turn Lane; Temporary configuration to consist of 3 Northbound Left-Turn Lanes, 3 Northbound Through Lanes and 2 Westbound Right-Turn Lanes. Will revert to 2 Northbound Left-Turn Lanes, 4 Northbound Through Lanes, and 1 Westbound Right-Turn Lane (existing configuration) when Cross-Valley Connector is completed. | |

## Table ES-1 (continued)
## Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.3 TRAFFIC/ACCESS (continued)** | | | |
| Mitigation that will reduce the project's impact to a level of insignificance is presently infeasible at the above-identified four intersections for the following reasons. First, the identified mitigation requires the acquisition of additional property for right-of-way, property not controlled by the applicant. Eminent domain may reasonably be seen as necessary to make the necessary acquisitions. Second, the mitigation would require relocation of on-site improvements on properties at the affected intersections. Finally, the mitigation could force the relocation of existing businesses at the affected intersections. Affected intersections are illustrated with photographs depicting right-of-way encroachment in **Appendix 4.3, Traffic/Access.**<br><br>The City has determined that the affected intersections are built-out and generally recognizes the infeasibility of additional improvements at such intersection, with the exception of the Bouquet Canyon Road/Soledad Canyon Road intersection. The Bouquet Canyon Road/Soledad Canyon Road intersection improvements are expected to occur in Spring 2004. Upon completion of these improvements, this intersection will be considered built out. The City of Santa Clarita General Plan Circulation Element states, "Existing street improvements are, in some cases, not able to be modified to accommodate additional traffic or circulation movements due to right-of-way limitations and existing development." | | | |
| | | **Interim Year** | |
| | 4.3-7 | McBean Parkway & Newhall Ranch Road: Add 4th Eastbound Through Lane. Add 4th Westbound Through lane. | Significant |
| | 4.3-8 | Valencia Boulevard & Magic Mountain Parkway: Add 3rd Eastbound Through Lane (requires right-of-way on south side of Valencia Boulevard, presently infeasible). | |
| | 4.3-9 | Seco Canyon Road & Bouquet Canyon Road: Add 1st Westbound Right-Turn Lane (requires right-of-way, presently infeasible). Convert 1st Southbound Right-Turn Lane to a shared Left-Turn/Right-Turn Lane (for 1 Left-Turn Lane, 1 shared Left-Turn Lane/Right-Turn Lane, 1 Right-Turn Lane). | |
| | 4.3-10 | Bouquet Canyon Road & Soledad Canyon Road: Add 4th Northbound Through Lane. (Requires right-of-way on Southeast Corner of Intersection along Bouquet Canyon Road, presently infeasible.) | |
| | 4.3-11 | Bouquet Canyon Road & Newhall Ranch Road: Add 4th Eastbound Through Lane and Add 4th Westbound Through Lane. | |
| | 4.3-12 | Whites Canyon & Soledad Canyon Road: Add 2nd dedicated Northbound Left-Turn Lane & convert shared Northbound Left-Turn/Through Lane to 3rd dedicated Through Lane (requires right-of-way on southeast side of intersection along Whites Canyon Road, presently infeasible) or Add 1st Eastbound Right-Turn Lane (requires right-of-way on southwest corner of intersection along Soledad Canyon Road, presently infeasible). | |
| | | **Alternative Interim Year (Not a Part of the Proposed Project)** | |
| | 4.3-13 | McBean Parkway & Newhall Ranch Road: Add 4th Eastbound Through Lane. Add 4th Westbound Through Lane. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.3 TRAFFIC/ACCESS** | | |
| This language in the adopted General Plan acknowledges that the benefits of improvements at such intersections are not outweighed by a combination of the potential time and cost of actions that may necessary to acquire the property, the physical and economic costs to businesses at the affected intersections, and the social costs that could occur if businesses were forced to relocate in order to continue to operate.<br><br>Consequently, these improvements will not be able to be made and impacts would be unavoidable and significant and a statement of overriding considerations would be necessary. | 4.3-14 Valencia Boulevard & Magic Mountain Parkway: Add 3rd Eastbound Through Lane (requires right-of-way on south side of Valencia Boulevard, presently infeasible). | |
| | 4.3-15 Seco Canyon Road & Bouquet Canyon Road: Convert 1st Southbound Right-Turn Lane to a shared Left-Turn/Right-Turn Lane (for 1 Left-Turn Lane, 1 shared Left-Turn Lane/Right-Turn Lane, 1 Right-Turn Lane). | |
| | 4.3-16 Bouquet Canyon Road & Soledad Canyon Road: Add 4th Northbound Through lane (requires right-of-way on Southeast Corner of Intersection along Bouquet Canyon Road, presently infeasible). | |
| | 4.3-17 Bouquet Canyon Road and Newhall Ranch Road: Add 4th Eastbound Through Lane Add 4th Westbound Through Lane. | |
| | **c. Other Mitigation** | |
| | 4.3-18 Applicable transit mitigation fees will be paid at the time of final map recordation. | |
| | 4.3-19 If additional fixed route service will be needed near the project site in the future, as determined by the City of Santa Clarita, the project developer(s) shall coordinate with the transit provider to identify appropriate bus stop/turnout locations. | |
| | **d. Cumulative Mitigation** | |
| | 4.3-20 The project shall fund its calculated fair share of improvements to augment the capacities of affected roadways. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.4 AIR QUALITY** | | |
| Construction-related emissions would be generated by on-site stationary sources, on- and off-road heavy-duty construction vehicles, and construction worker vehicles. Operation-related emissions would be generated by on-site and off-site stationary sources and by mobile sources. During the 51-month construction phase, emissions of carbon monoxide (CO), volatile organic compounds (VOC), oxides of nitrogen ($NO_x$) and particulate matter (10 micron) ($PM_{10}$) would exceed thresholds of significance recommended by the South Coast Air Quality Management District (SCAQMD) for approximately 13, 36, 26, and 12 months, respectively. At project buildout, operational emissions of CO, VOC, $NO_x$, and $PM_{10}$ would exceed SCAQMD thresholds, primarily due to mobile source emissions in the summertime and, in the wintertime, to mobile source and fireplace/wood-burning stove emissions.<br><br>Feasible mitigation measures would be implemented that would reduce construction-related and operational-related emissions to the maximum extent feasible. However, no feasible mitigation exists which would reduce the project's construction-related emissions of VOC, $NO_x$, or $PM_{10}$ to below the SCAQMD's recommended thresholds of significance. No feasible mitigation exists to reduce the project's operational emissions of CO, VOC, or $NO_x$ to less than significant. Therefore, the project's construction-related and operation-related emissions would be considered unavoidably significant. | The SCAQMD has also prepared a list of measures that could be implemented by new projects to reduce the impacts of operation-related emissions. Measures already incorporated in the project include retail services in close proximity to a residential subdivision; constructing off-site bicycle trails linking the project to designated bicycle routes; providing through paseos a safe, pedestrian-friendly environment; bus stops and providing shade trees to reduce building heating/cooling needs.<br><br>**a. Mitigation for Construction Impacts**<br><br>The SCAQMD has prepared a list of measures to reduce the impacts of construction-related emissions to the greatest extent possible. Those that could be feasibly implemented during the development of the project are as follows:<br><br>4.1-1 To the maximum extent feasible, develop and implement a construction management plan, as approved by the City, which includes the following measures recommended by the SCAQMD, or equivalently effective measures approved by the SCAQMD:<br><br>a. Configure construction parking to minimize traffic interference.<br>b. Provide temporary traffic controls during all phases of construction activities to maintain traffic flow (e.g., flag person).<br>c. Schedule construction activities that affect traffic flow on the arterial system to off-peak hours.<br>d. Re-route construction trucks away from congested streets. | Significant |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.4 AIR QUALITY (continued)** | | | |
| | | e. Consolidate truck deliveries when possible.<br>f. Provide dedicated turn lanes for movement of construction trucks and equipment on- and off-site.<br>g. Maintain equipment and vehicle engines in good condition and in proper tune as per manufacturers' specifications and per SCAQMD rules, to minimize exhaust emissions.<br>h. Suspend use of all construction equipment operations during second stage smog alerts. Contact the SCAQMD at 800/242-4022 for daily forecasts.<br>i. Use electricity from power poles rather than temporary diesel- or gasoline-powered generators.<br>j. Use methanol- or natural gas-powered mobile equipment and pile drivers instead of diesel if readily available at competitive prices.<br>k. Use propane- or butane-powered on-site mobile equipment instead of gasoline if readily available at competitive prices. | |
| The SCAQMD's criteria of annual emission reductions of one percent for CO, VOC, $NO_x$, $PM_{10}$, and oxides of sulfur ($SO_x$), were used to assess cumulative air quality impacts. Through site planning, proposed design features, and with implementation of the mitigation measures recommended in this section, the project would reduce wintertime emissions for CO, VOC, $NO_x$, and $PM_{10}$ by 75.3, 91.8, 29.5, and 85.3 percent, respectively. During the summer, these emissions would be reduced by 4.6, 17.7, 9.3, and 4.2 percent, respectively. Therefore, cumulative air quality impacts would not be significant given the cumulative project thresholds of significance of the SCAQMD's CEQA Air Quality Guidelines, and the fact that the project's population forecast is consistent with the SCAQMD's 2003 Air Quality Management Plan. However, because the project's operational-related CO, VOC, $NO_x$, and $PM_{10}$ emissions would exceed the SCAQMD's project-specific thresholds of significance, even with all feasible mitigation, project implementation will result in a cumulatively significant and unavoidable air quality impact. This is considered a conservative and "worst-case" approach for estimating the project's cumulative air quality impacts. | 4.4-2 | To the maximum extent feasible, develop and implement a dust control plan, as approved by the City, which includes the following measures recommended by the SCAQMD, or equivalently effective measures approved by the SCAQMD:<br><br>a. Apply approved non-toxic chemical soil stabilizers according to manufacturer's specification to all inactive construction areas (previously graded areas inactive for four days or more).<br>b. Replace ground cover in disturbed areas as quickly as possible.<br>c. Enclose, cover, water twice daily, or apply approved soil binders to exposed piles (i.e., gravel, sand, dirt) according to manufacturers' specifications.<br>d. Water active grading sites at least twice daily.<br>e. Suspend all excavating and grading operations when wind speeds (as instantaneous gusts) exceed 25 mph.<br>f. Provide temporary wind fencing consisting of 3- to 5-foot barriers with 50 percent or less porosity along the perimeter of sites that have been cleared or are being graded.<br>g. All trucks hauling dirt, sand, soil, or other loose materials are to be covered or should maintain at least two feet of freeboard (i.e., minimum vertical distance between top of the load and the top of the trailer), in accordance with Section 23114 of the California Vehicle Code. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.4 AIR QUALITY (continued)** | | |
| | h. Sweep streets at the end of the day if visible soil material is carried over to adjacent roads (recommend water sweepers using reclaimed water if readily available).<br>i. Install wheel washers where vehicles enter and exit unpaved roads onto paved roads, or wash off trucks and any equipment leaving the site each trip.<br>j. Apply water three times daily or chemical soil stabilizers according to manufacturers' specifications to all unpaved parking or staging areas or unpaved road surfaces.<br>k. Enforce traffic speed limits of 15 mph or less on all unpaved roads.<br>l. Pave construction roads when the specific roadway path would be utilized for 120 days or more. | |
| | 4.4-3 Comply with Title 24 of the UBC energy conservation requirements. | |
| | 4.4-4 Restaurants with an under-fired charbroiler shall obtain a permit from the SCAQMD prior to an issuance of an occupancy permit. | |
| | 4.4-5 Gas stations shall obtain a permit from the SCAQMD prior to issuance of an occupancy permit. | |
| | 4.4-6 Any dry cleaners proposing to locate on site shall conduct cleaning operations at an off-site previously SCAQMD permitted location. No on-site dry cleaning operations will be permitted to occupy space in the commercial area. | |
| | 4.4-7 Applicable transit mitigation fees shall be paid at the time of final map recordation. | |
| | 4.4-8 All on- and off-road construction equipment shall to the extent feasible, as determined by the City of Santa Clarita use aqueous fuel. | |
| | Aqueous fuel is a stable emulsion of up to 55 percent water and petroleum-based naphtha (a petroleum product from the earliest stages of the refinery process), with trace amounts of bonding and winterizing agents. It can be used to run both gasoline and diesel engines. Aqueous fuel is clean-burning and, based on information provided in the URBEMIS2002 model for its use in construction equipment, it can reduce $NO_x$ emissions by 14 percent and $PM_{10}$ emissions by 63 percent. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.4 AIR QUALITY (continued)** | | |
| | 4.4-9 All on- and off-road construction equipment shall, to the extent feasible as determined by the City of Santa Clarita, employ cooled exhaust gas recirculation technology.<br><br>Cooled exhaust gas recirculation (EGR) reduces CO, VOC, $NO_x$, and $PM_{10}$ emissions as follows: Oxygen is required for fuel to be burnt in a combustion engine. The high temperatures found within combustion engines cause nitrogen in the surrounding air to react with any unused oxygen from the combustion process to form $NO_x$. EGR technology directs some of the exhaust gases that have already been used by the engine and no longer contain much oxygen back into the intake of the engine. By mixing the exhaust gases with fresh air, the amount of oxygen entering the engine is reduced. Since there is less oxygen to react with, fewer nitrogen oxides are formed, the amount of nitrogen oxides that a vehicle releases into the atmosphere is decreased. Based on information provided in the URBEMIS2002 model for its use in construction equipment, cooled exhaust gas recirculation technology can reduce CO and VOC emissions by 90 percent, $NO_x$ emissions by 40 percent and $PM_{10}$ emissions by 85 percent.<br><br>Because **Mitigation Measures 4.4-8** and **4.4-9** are based on technology unproven on a large scale, these mitigation measures may be infeasible. | |
| | **b. Mitigation for Operation Impacts**<br><br>**Stationary Sources**<br><br>The following are additional SCAQMD measures and others that may be feasibly implemented by the project. Other potential measures listed in the CEQA Air Quality Handbook were not applicable to the project due to the type or size of proposed development and were considered infeasible. These measures are identified in the Estimated Emissions Reductions Efficiencies spreadsheet in **Appendix 4.4** along with explanations of why they are infeasible and not applicable to the project. | |
| | 4.4-10 Utilize low emission water heaters in residential and commercial uses to reduce natural gas consumption and emissions. | |
| | 4.4-11 Residential uses are to utilize built-in energy-efficient appliances (e.g., stoves, ovens, refrigerators) to reduce energy consumption and emissions. | |

## Table ES-1 (continued)
## Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.4 AIR QUALITY (continued)** | | |
| | 4.4-12 Residential uses are to utilize energy-efficient and automated controls for air conditioners to reduce energy consumption and emissions. | |
| | 4.4-13 Wood-burning fireplaces and stoves shall be prohibited in all residential units. Use of wood in fireplaces and wood-burning stoves shall be prohibited through project CC&Rs. Permits shall not be issued by the City of Santa Clarita for wood-burning stoves. | |
| | 4.4-14 Install special sunlight-filtering window coatings or double-paned windows in residential uses to reduce thermal gain or loss. | |
| | 4.4-15 Utilize automatic lighting on/off controls and energy-efficient lighting in new residential common area construction (including parking areas) to reduce electricity consumption and associated emissions. | |
| | 4.4-16 To the extent feasible, orient living spaces in residential structures so they face to the north. | |
| | 4.4-17 Use light-colored roofing materials in new residential construction as opposed to dark roofing materials. These materials would reflect, rather than absorb, sunlight and minimize heat gains in buildings. This measure would lessen the overall demand for mechanical air conditioning systems. | |
| | 4.4-18 Multi-family and commercial uses shall use central water heating systems. | |
| | **Mobile Sources** | |
| | 4.4-19 If Santa Clarita Transit determines that additional fixed route service will be needed near the project site in the future, the project developer(s) shall coordinate with the transit provider to identify and provide for appropriate bus stop/turnout locations. | |
| | 4.4-20 Synchronize traffic lights on streets impacted by project development. | |
| | 4.4-21 The project applicant shall construct bicycle facility improvements, such as bike lanes in roadways and wider-than-required sidewalks with bike paths within and adjacent to residential subdivisions at the time the roads are constructed. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| 4.4 AIR QUALITY (continued) | | |
| | 4.4-22 Kiosks with local transit and Metrolink information shall be constructed by the project applicant adjacent to selected future bus stops prior to initiation of bus service to the site. | |
| | 4.4-23 The sellers of new residential units shall distribute brochures and other relevant information published by the SCAQMD or similar organization to new homeowners regarding the importance of reducing vehicle miles traveled, energy saving appliances, and related air quality impacts, as well as information on local opportunities for public transit and ridesharing. | |

## Table ES-1 (continued)
## Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.5 NOISE** | | | |
| Mitigation measures recommended to reduce construction-related noise impacts would reduce the magnitude of those impacts; however, the potential for construction-related noise levels to exceed normally acceptable noise levels in the Noise Element Guidelines would remain. Therefore, construction-related noise impacts are considered unavoidably significant. Even with construction of the sound walls as proposed and with implementation of the mitigation measures recommended in this section, the project would result in unavoidably significant long-term mobile source noise impacts both on and off the project site. In addition, should they occur, on-site noise levels in excess of 55 dB(A) CNEL from activities at Saugus Speedway would be unavoidably significant under Section 11.44.040 of the Noise Ordinance. | a. | **Mitigation Measures Already Incorporated into the Project** | Significant |
| | 4.5-1 | Lots 1 and 2 (Area A1): A 6-foot high continuous solid masonry wall along the rear yard lot lines of Lots 1 and 2 and wrapping around Lot 1 to "C" Street. | |
| | 4.5-2 | Lots 56, 57, and 60 to 72 (Area A1): A 7-foot high masonry wall and 3-foot high continuous berm along the rear yards of Lots 56, 57, and 60 to 72, wrapping around the rear yard of Lot 56 as it backs on to "A" Street. | |
| | 4.5-3 | Lots 158 to 176 (Area A1): A 7-foot high masonry wall and 3-foot high continuous berm along Newhall Ranch Road and the western lot line of Lot 176. | |
| Because noise levels at many sensitive receptors in the project study area already exceed normally acceptable levels under the Noise Element's Noise and Land Use Compatibility Guidelines, any noise increases as a result of cumulative projects would result in significant and unavoidable noise impacts at sensitive receptors along the following roadway segments:<br>• Bouquet Canyon Road n/o Newhall Ranch Road,<br>• Bouquet Canyon Road e/o Seco Canyon Road,<br>• Bouquet Canyon Road e/o Santa Clarita Parkway,<br>• Bouquet Canyon Road s/o Soledad Canyon Road,<br>• Golden Valley Road w/o SR-14,<br>• Magic Mountain Parkway w/o San Fernando Road,<br>• Newhall Ranch Road w/o Hillsborough Way,<br>• Newhall Ranch Road w/o Bouquet Canyon Road,<br>• Rainbow Glen Drive s/o Soledad Canyon Road,<br>• Seco Canyon Road n/o Bouquet Canyon Road,<br>• Soledad Canyon Road e/o Santa Clarita Parkway,<br>• Soledad Canyon Road e/o Rainbow Glen Drive,<br>• Soledad Canyon Road w/o Whites Canyon,<br>• Valencia Boulevard s/o Magic Mountain Parkway,<br>• Via Princessa e/o Rainbow Glen Drive,<br>• Via Princessa w/o Whites Canyon Road, and<br>• Whites Canyon Road n/o Soledad Canyon Road. | 4.5-4 | Lot 132 (Area A1): A 6-foot high continuous solid masonry wall along Newhall Ranch Road extending approximately 200 feet easterly from the 10-foot wall/berm at the northeastern corner of Lot 158. | |
| | 4.5-5 | Lots 251 to 260 (Area A2): A 7-foot high masonry wall and 3-foot high continuous berm along the western edge of Santa Clarita Parkway from a point across from "Q" Street to the southeastern corner of Lot 251, wrapping continuously around the southern lot line of Lot 251. | |
| | 4.5-6 | Lots 294, 295, 313, 314, 337, and 338 (Area A2): A 6-foot high continuous solid masonry wall along the property lines of Lots 294, 295, 313, 314, 337, and 338 along Santa Clarita Parkway at the proposed pad elevations for each lot. | |
| | 4.5-7 | Lots 368, 375 to 378 (Area B): A 6-foot high continuous solid masonry wall along the side and rear of Lot 368, and the rear lot lines of Lots 375 to 378. | |
| | 4.5-8 | Lot 457 (Area B): A 6-foot high continuous solid wall along the southern rear yard of Lot 457 that backs onto "R" Street. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.5 NOISE (continued)** | | |
| | 4.5-9 Lots 441, 442, 448, 449, 456, and 457 (Area B): A 7-foot high masonry wall and 3-foot high continuous berm along Santa Clarita Parkway along Lots 441, 442, 448, 449, 456, and 457. The berm/masonry wall also "wraps around" the northern boundary of Lot 441 as it backs onto "Q" Street. | |
| | 4.5-10 Lot 434 (Area B): A 6-foot high continuous solid masonry wall along the southern boundary of Lot 4334 as it backs onto "Q" Street. | |
| | 4.5-11 Lots 421 to 434 (Area B): A 7-foot high masonry wall and 3-foot high continuous berm along the rear lot lines of Lots 421 to 434 that back onto Santa Clarita Parkway and Newhall Ranch Road. | |
| | 4.5-12 Area B: A 7-foot high masonry wall and 3-foot high continuous berm along Newhall Ranch Road from the northeastern corner of Lot 421 to the northwestern corner of Lot 513. | |
| | 4.5-13 Lot 521 (Area C): A 6-foot high continuous solid masonry wall at the top of slope along the frontage of Lot 521 with Newhall Ranch Road and "wrapping around" the driveway entrance for a distance of approximately 150 feet. | |
| | 4.5-14 Lot 519 (Area C): A 6-foot high continuous solid masonry wall at the top of slope along the frontage of Lot 519 with Newhall Ranch Road and Future Golden Valley Road, and "wrapping around" the driveway entrance for a distance of approximately 150 feet. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.5 NOISE (continued)** | | |
| | **b. Construction Noise Mitigation** | |
| | 4.5-15 Pursuant to Section 11.44.080 of the City's Noise Ordinance, no construction work shall occur within 300 feet of occupied residences except between the hours of 7:00 AM and 7:00 PM Monday through Friday, and between 8:00 AM and 6:00 PM on Saturday. No construction work shall occur on Sundays, New Year's Day, Independence Day, Thanksgiving Day, Christmas Day, Memorial Day, and Labor Day. | |
| | 4.5-16 When construction operations occur within 300 feet of on- or off-site occupied residences, and when it is determined by City staff during routine construction site inspections that the construction equipment could generate a noise level at those residences that would be in excess of normally acceptable noise levels of the City's Noise and Land Use Compatibility Guidelines, implement appropriate additional noise reduction measures. These measures shall include among other things changing the location of stationary construction equipment, shutting off idling equipment, notifying residents in advance of construction work, and installing temporary acoustic barriers around stationary construction noise sources. | |
| | 4.5-17 Locate construction staging areas on site to maximize the distance between staging areas and occupied on- and off-site residences, including those within the adjacent mobile home park and the Emblem tract. | |
| | **c. Operational Noise Mitigation** | |
| | In addition to the traffic mitigation measures included in **Section 4.3, Traffic/Access**, the following measures are recommended to ensure that operational noise levels, experienced at buildout with future traffic volumes, do not exceed the normally acceptable noise levels set forth in the Noise Element Guidelines. | |
| | 4.5-18 Lot 60 (Area A1): A 6-foot high continuous masonry wall shall be constructed along the western side yard of Lot 60. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.5 NOISE (continued)** | | |
| | 4.5-19 Balconies are considered exterior living areas and must also meet the exterior noise standard. Therefore, balconies shall either be discouraged on residential units where they would be exposed to exterior noise levels greater than the 60 dB(A) CNEL standard for single family residences or the 65 dB(A) CNEL standard for multi-family residences through architectural or site design, or balconies in such areas shall be enclosed by solid noise barriers, such as 3/8-inch glass or 5/8-inch Plexiglas to a height specified by a qualified noise consultant. | |
| | 4.5-20 Interior noise environments of all residential units within the project shall not exceed 45 dB(A). | |
| | 4.5-21 Prior to issuance of building permits, a detailed acoustic analysis shall be performed for all residence in areas subject to noise levels in excess of normally acceptable noise levels for that use. The analysis shall be based upon final site grades, building orientation, and noise exposure, and shall specify all practical noise insulation features necessary to ensure interior residential noise environments do not exceed 45 dB(A). These noise insulation features may include, but are not limited to, the following:<br>a. All windows, both fixed and operable, shall consist of either double-strength glass or double-paned glass. All windows facing sound waves generated from the mobile source noise shall be manufactured and installed to specifications that prevent any sound from window vibration caused by the noise source.<br>b. Doors shall solid core and shall be acoustically designed with gasketed stops and integral drop seals.<br>c. If necessitated by the architectural design of a structure, special insulation or design features shall be installed to meet the required interior ambient noise level.<br>d. The exterior walls of living areas shall be of a special type construction and/or include special insulation, depending on the maximum ambient noise levels generated at any time in a particular area. | |
| | 4.5-22 Air conditioning units shall be installed to serve all living areas of all residences with direct lines of sight to Newhall Ranch Road, Santa Clarita Parkway, Golden Valley Parkway, or Soledad Canyon Road. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.5 NOISE** | | |
| | 4.5-23 Delivery Truck Noise Impacts on Lot 525 (Area D): A minimum 6-foot high solid masonry wall with a 2-foot berm shall be constructed along the western edge of Lot 525 (multi-family, Area D) between the off-site commercial use to the west and the apartment units. | |
| | 4.5-24 Prior to final map approval, another noise impact analysis on the tract shall be performed by a qualified acoustical consultant to ensure noise levels within the project are consistent with this analysis and the City's Noise Element Guidelines. | |
| | 4.5-25 Prior to sale of any single-family residential lot within Riverpark, future homeowners shall be informed via language in the disclosure documents the presence of the Saugus Speedway facility, the types of events that can potentially occur at the speedway, the expected frequency of their occurrence, and that noise from events at the speedway may be intermittently audible at their properties during daytime, evening, and late night hours. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.6 BIOLOGICAL RESOURCES** | | | |
| All impacts that are associated with the implementation of this proposed project can be mitigated to a level less than significant except the following:<br>• The total net loss of 280 acres of wildlife habitat/natural open space as a result of conversion of undeveloped property to developed. Though over 400 acres of the site will remain as open space and some of the habitat can be restored and enhanced within remaining open space areas of the site, and measures exist to replace the loss of some habitat, there will still be a net loss of habitat for wildlife and open space that cannot be replaced. This net loss represents a significant unavoidable impact.<br>• Impacts to riverine habitat (as identified by the resource line) and associated riverbed. While riparian vegetation can be planted and enhanced along preserved portions of the river, there will still be a net loss of 25.5 acres of riparian and riverbed habitat that ultimately cannot be replaced. This net loss represents a significant unavoidable impact.<br>• Impacts to adjacent upland habitat within 100 feet of the riparian resource line. While the 100-foot setback threshold will be upheld in several areas along the river, this threshold will not be met along substantial portions of the project. Those portions of the project site that provide less than 100 feet of preserve upland habitat adjacent to the resource line represent a significant unavoidable impact. | a. | **Mitigation Measures Incorporated into the Project** | |
| | 4.6-1 | To minimize significant impacts of the project on biological resources, the applicant has incorporated the following measures from the NRMP into this Draft EIR:<br>a. Construction activities in the riverbed shall be restricted to the following areas of temporary disturbance: (1) an 85-foot-wide zone that extends into the river from the base of the rip-rap gunite or soil cement bank protection from where it intercepts the river bottom; (2) 100 feet on either side of the outer edge of a new bridge or bridge to be modified; (3) 50-foot-wide corridor for all utility lines; and (4) 20-foot-wide temporary access ramps and roads to reach construction sites. The locations of these temporary construction sites and the routes of all access roads shall be shown on maps submitted with the Verification Request Letter submitted to the ACOE and CDFG for individual project approval. The construction plans should indicate what type of vegetation, if any, would be temporarily disturbed and the post-construction activities to facilitate natural revegetation of the temporarily disturbed areas.<br>b. All native riparian trees in temporary construction areas with a 4-inch dbh or greater shall be replaced at a 3:1 ratio using 1 to 5 gallon container plants in the temporary construction areas in the winter following the construction disturbance. The growth and survival of the replacement trees shall meet the performance standards specified in later mitigation measures. In addition, the growth and survival of the planted trees shall be monitored for five years in accordance with the methods and reporting procedures specified in a later mitigation measure. | Significant |

## Table ES-1 (continued)
## Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|

### 4.6 BIOLOGICAL RESOURCES (continued)

Indirect impacts associated with this cumulative project are not quantifiable but are reasonably foreseeable. Such impacts would come primarily through an increase in vehicular traffic across the bridge route itself and the increase light and glare cause by its use. Stormwater runoff from the bridge and roadway would also occur. Various pollutants related to vehicular traffic (e.g., rubber from tires, hydrocarbons from engine exhaust, etc.) would be expected to wash off the road surface into the river and degrade habitat if left unmitigated. Construction activities themselves would also be expected to temporarily and permanently impact habitat along the river corridor. As with the proposed project alone, impacts cause by this cumulative project would, in combination with the proposed project, result in significant indirect biological impacts. A total of 2.8 acres of habitat within Santa Clara River SEA will be disturbed or converted to urban use as a result of Santa Clarita Parkway Bridge construction. Approximately 0.5 acre will be temporarily disturbed as a result of proposed bank stabilization activities and will be replaced upon completion of the bank stabilization to protect the bridge structure. Within the SEA boundaries, a total of 1.5 acres of riverwash, 0.2 acre of southern riparian scrub, and 0.5 acres of disked field representing a total of 2.2 acres of SEA habitat will be permanently lost as a result of this cumulative project. The locations of these impacts are generally along the northern and southern bank of the Santa Clara in the central portion of the project site.

Because of the relatively small amount of each habitat type within the SEA to be removed, like with the proposed project, the permanent loss of an additional 2.2 acres of habitat within the SEA boundaries is not expected to detract from the overall integrity and value of the SEA, in and of itself. In particular, this loss of area will not adversely affect the unarmored three-spine stickleback, the state and federally listed Endangered fish species for which the SEA was originally designed to protect. However, because of the overall sensitivity of SEAs, and because any permanent loss of habitat within a SEA will effectively reduce the overall size of the SEA, any net loss of land within a SEA is considered a significant impact. Therefore, the permanent loss of an additional 2.2 acres of SEA habitat is considered a significant cumulative impact.

c. Native vegetation within temporary construction areas shall be mulched and spread over the temporary impact areas once construction is completed in order to facilitate revegetation. Areas temporarily disturbed by construction activities shall also be weeded annually, as needed, for up to five years following construction. These areas shall be annually monitored for five years after construction to document colonization by weeds and native plants. Weeds shall be removed by hand, an approved herbicide application, and/or by equipment. In the event that native plant cover does not reach 50 percent of the pre-construction native plant cover within three years, the applicant shall revegetate the temporary construction area in accordance with the methods specified in later mitigation measures. Annual monitoring reports on the status of the natural recovery of temporarily disturbed areas shall be submitted to the ACOE and CDFG as part of the Annual Mitigation Status Report and Mitigation Accounting Form to be submitted to the ACOE and CDFG by April 1st of each year.

d. Permanent removal of riparian habitats shall be replaced by creating riparian habitats of similar functions and values in the project area. Wetland restoration shall be in-kind and at a 1:1 replacement ratio (except as indicated in **Item f.**, below, for new habitat installed two years in advance of the removal of habitat at the construction site. If replacement habitat cannot be installed two years in advance of the project, the ratios listed below will apply. As described in **Item c.**, lower replacement ratios may be appropriate if an ACOE-approved hydrogeomorphic method (HGM) of assessing replacement ratios indicates lower ratios would ensure replacement of habitat values and functions.

| Timing Mitigation | Value of Habitat of Affected | Proposed Ratio Required for Revegetation |
|---|---|---|
| Habitat installation completed 2 years or more prior to construction impact | N/A | 1:1 |
| Habitat installation completed less than 2 years in advance of impact | Low | 1:1 |
| | Medium | 2:1 |
| | High | 3:1 |

* High (NRMP EIS/EIR mapping units 1, 2, 3, 6), Medium (NRMP EIS/EIR mapping units 4, 7), Low (NRMP EIS/EIR mapping units 5, 8)

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)**<br>Potentially significant cumulative impacts could occur to various environmental biological resources due to the combined impacts of the proposed project and following nearby projects: Santa Clarita Parkway extension, Tesoro del Valle, Newhall Ranch Specific Plan, West Creek, North Valencia II Specific Plan, Valencia Commerce Center, and Curtis Sand and Gravel Mine Expansion. These resources include upland habitats such as coastal sage scrub, oak trees, riparian habitat associated with Santa Clara River, wildlife movement corridors, special-status species (including unarmored three-spine stickleback and arroyo toad), resources within SEA 23, and increased use of sensitive riparian resources by human and domestic animals. Potentially significant cumulative impacts include loss of riparian habitat, disturbance of riparian wildlife habitat due to nearby urban development, and effects on habitat for the unarmored three-spine stickleback, least Bell's vireo, and the arroyo toad, when present. While most of these projects include the implementation of measures that will mitigate specific biological impacts, most will still result in a net loss of biological resources, particularly natural habitat areas.<br><br>Because of the high biological value of riparian and wetland habitats and because of the continued loss of these habitats throughout the region, the proposed Riverpark project's contribution to this loss, although relatively small, is considered a significant cumulative impact, both to the vegetation community itself, as well as to its value to the riparian ecosystem. Because of the time it takes for oak trees to reach maturity and contribute biological values equal to that currently occurring on the site, and due to continued loss of these trees in the region, the project's contribution to this loss is considered a significant cumulative impact. Continued development in the area also cumulatively contributes to the increase of humans and domestic animals. Because of the substantial amount of disturbance to sensitive resource areas posed by this increase, the project's contribution to this increase is also considered cumulatively significant. Although the proposed project minimizes impacts to the biological resources within the SEA, the net loss of habitat within the SEA, combined with net losses of SEA habitats from other projects, effectively reduces the overall size of the SEA and is considered a significant cumulative impact. | e. Creation of new riparian habitats shall occur at suitable sites in or adjacent to the watercourses included in the NRMP. Habitat restoration sites in the riverbed shall only be located in areas where the predominant habitats present are dry open floodplain, weedy herbaceous, or their functional equivalent. The highest priority habitat restoration sites should be new riverbed areas created during the excavation of uplands for bank protection. Restoration sites may also occur at locations outside the riverbed where there is appropriate hydrologic conditions to create a self-sustaining riparian habitat and where upland and riparian habitat values are absent or very low. All sites shall contain suitable hydrological conditions and surrounding land uses to ensure a self-sustaining functioning riparian habitat. Candidate restoration sites shall be selected by the applicant described in the Annual Mitigation Status Report that will be submitted to the ACOE by April 1st of each year. Sites will be approved when restoration plans are submitted to the ACOE and CDFG as part of the Verification Request Letters submitted for individual projects, or as part of the Annual Mitigation Status Report and Mitigation Accounting Form. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)**<br>When the potential cumulative effects of the above mentioned projects are viewed from a regional wildlife movement perspective, the major movement corridors between the Santa Clara River Valley and the Santa Susana Mountains and Los Padres/Angeles National Forest lands would still be preserved. Therefore, no significant cumulative impacts would occur with respect to regional wildlife movement. | f. Replacement habitat shall be designed to replace the functions and values of the habitats being removed. At this time, the replacement habitat shall be restored in accordance with the acreage replacement ratios described in **Item a**. The replacement habitats shall have similar dominant trees and understory shrubs and herbs as the affected habitats. In addition, the replacement habitats shall be designed to replicate the density and structure of the affected habitats once the replacement habitats have reached mature status. Replacement ratios that are lower than those listed in **Item a.** may be used if an ACOE-approved hydrogeomorphic method (HGM) is applied in which habitat functions and values of both the affected habitat and the replacement habitat are quantified.<br>g. Average plant spacing shall be determined based on an analysis of habitats to be replaced. Typical plant spacing is presented below for use in developing willow-cottonwood woodland habitat as an example only. The applicant shall develop similar tree spacing specifications for habitats to be restored. Plant spacing specifications shall be reviewed and approved by the ACOE and CDFG when restoration plans are submitted to the ACOE as part of the Verification Request Letters submitted to the ACOE and CDFG for individual projects or as part of the Annual Mitigation Status Report and Mitigation Accounting Form. | |

| Species | Average Plant Spacing (feet) | Height (feet) After 3 years | Height (feet) After 5 years |
|---|---|---|---|
| Arroyo willow | 8 | 10 | 15 |
| Black willow | 8-10 | 12 | 18 |
| Sandbar willow | 8 | 4 | 6 |
| Red willow | 8 | 9 | 15 |
| Cottonwood | 20 | 7 | 12 |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| 4.6 BIOLOGICAL RESOURCES (continued) | | |
| | h. Each tree and shrub species used in restoration shall have a minimum of 80 percent survival after three years and 70 percent survivorship after five years. Key indicator tree species to be used in the riparian restoration program shall achieve a minimum growth at the end of three years and five years, as described above in **Item e**. Performance standards for cover shall be developed for each individual habitat type being created, based on the observed natural cover in undisturbed habitats in the project area. These standards shall be approved by the ACOE and CDFG after they have reviewed the Annual Mitigation Status Report and Mitigation Accounting Form Minimum growth, survivorship, and cover performance at the mitigation sites shall be measured based on random samples taken during years three and five at each individual mitigation site, or at other sampling intervals if the ACOE' hydrogeomorphic methodology is used by the applicant. | |
| | i. If the minimum growth, survivorship, and/or cover are not achieved at the time of the three and five year evaluations, then the applicant shall be responsible for taking the appropriate corrective measures as to achieve the specified growth, survivorship, and/or cover criteria. The applicant shall be responsible for any costs incurred during the revegetation or in subsequent corrective measures. If acts of God (flood, fires, or drought) occur after the vegetation has met the three-year criteria for growth, survival, and cover, the applicant will not be responsible for replanting damaged areas. If these events occur prior to the plants meeting the three-year criteria, the applicant shall be responsible for replanting the area one time only. | |
| | j. The applicant shall be responsible for weeding all restoration sites to prevent an infestation of non-native weeds for a period of five years after the initial habitat restoration, regardless of the success of the planted species. The cover of non-native plant species at the mitigation sites shall not exceed 10 percent at any time, within this five-year period. | |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | k. Temporary irrigation shall be installed, as necessary, for plant establishment. Irrigation shall continue as needed to meet the three and five-year performance criteria regarding survivorship and growth. Irrigation shall be terminated in the winter to provide the least stress to plants. Removal of the irrigation system shall occur in conjunction with an appropriate "weaning" procedures to minimize plant stress. Irrigation shall be terminated at the earliest opportunity after achieving the five-year criteria. | |
| | l. As an alternative to the restoration of habitats to compensate for permanent removal of riparian habitats, the applicant (at the discretion of the ACOE and CDFG) may remove exotic plant species from the project area in locations: (1) where there is an infestation of exotics such as *Arundo donax* such that the natural habitat functions and values are substantially degraded and at risk, and where the cover of exotics is equal to or exceeds 25 percent of the ground; or (2) other areas where exotic removal would be strategic in a watershed approach to weed management, as determined by the ACOE and CDFG. The weed removal sites shall be selected in logical manner to ensure that the eradication of weeds from specific sites will contribute to the overall control of exotics in the NRMP watercourses. Removal areas shall be kept free of exotic plant species for five years after initial treatment. In addition, native riparian vegetation must become established through natural colonization and meet the revegetation plant cover goals established by the ACOE and CDFG under **Item f.** after five years. | |
| | m. The removal program shall utilize methods and procedures approved by the ACOE and CDFG to remove exotics, including but not limited to, mechanical equipment in specific areas, handcutting, and the application of herbicides to stumps. Exotic plant species removal credit will be given as shown below (except when weed removal is used to mitigate for loss of habitat for sensitive riparian bird species where the ACOE and CDFG may require higher ratios). Weed eradication plans shall be submitted to the ACOE and CDFG for approval as part of the Verification Request Letters submitted to the ACOE and CDFG. The plans shall describe the proposed methods and the conditions of the site to be treated. A monitoring program shall be implemented to document the effectiveness of the removal and the natural establishment of native vegetation in the weeded area. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|

4.6 BIOLOGICAL RESOURCES (continued)

| Value of Riparian Habitat to be Removed | Mitigation Ratios for Exotic Removal: 2 Years in Advance | Mitigation Ratios for Exotic Removal: <2 Years in Advance |
|---|---|---|
| High (NRMP EIS/EIR mapping units 1, 2, 3, 6) | 3:1 | 4:1 |
| Medium (NRMP EIS/EIR mapping units 4, 7) | 2:1 | 3:1 |
| Low (NRMP EIS/EIR mapping units 5, 8) | 1:1 | 2:1 |

n. Prior to initiating construction for the installation of bridges, storm drain outlets, utility lines, and/or bank protection, all construction sites and access roads within the riverbed, as well as all riverbed areas within 300 feet of the construction site and access road, shall be inspected by a qualified biologist for the presence of arroyo toads, unarmored three-spine stickleback and arroyo chub. The ACOE and the CDFG shall be notified of the inspection and shall have the option of attending. If either agency is not represented, the biologist shall file a written report of the inspection with the agency not in attendance within 14 days of the survey and no sooner than 30 days prior to any construction work in the riverbed.

o. Construction work areas and access roads shall be cleared of the species listed above immediately before the prescribed work is to be carried out, immediately before any equipment is moved into or through the stream or habitat areas, and immediately before diverting any stream water. The removal of such species shall be conducted by a qualified biologist using procedures approved by the ACOE and CDFG, and with the appropriate collection and handling permits. Species shall be relocated to nearby suitable habitat areas. A plan to relocate these species shall be submitted to the ACOE and CDFG for review and approval no later than 30 days prior to construction. Under no circumstances shall the unarmored three-spine stickleback be collected or relocated, unless USFWS personnel or their agents implement this measure.

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | p. All stream flows traversing a construction site or temporary access road shall be diverted around the site and under access roads (using a temporary culverts or crossings that allow fish passage). A temporary diversion channel shall be constructed using the least damaging method possible, such as blading a narrow pilot channel through an open sandy river bottom. The removal of wetland and riparian vegetation to construct the channel shall be avoided to the greatest extent feasible. The temporary channel shall be connected to a natural channel downstream of the construction site prior to diverting the stream. The integrity of the channel and diversion shall be maintained throughout the construction period. The original stream channel alignment shall be restored after construction, provided suitable conditions are present at the work site after construction. A temporary stream diversion plan shall be included in the Verification Request Letters submitted to the ACOE and CDFG. This procedure can only be implemented if: (1) there are assurances by the applicant that the fully protected unarmored three-spine stickleback will not be taken or possessed; or (2) USFWS personnel or their agents implement this measure.<br>q. A qualified biologist shall be present when any stream diversion takes place, and shall patrol the areas both within, upstream, and downstream of the work area to rescue any species stranded by the diversion of the stream water. Species that are collected shall be relocated to suitable downstream of the work area. Under no circumstances shall the unarmored three-spine stickleback be collected or relocated, unless USFWS personnel or their agents implement this measure. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| 4.6 BIOLOGICAL RESOURCES (continued) | | |
| | r. The removal of any riparian habitat suitable for breeding, nesting, foraging, and temporary usage during migration by special-status species from the project footprint (i.e., boundaries of temporary and permanent impacts) shall be mitigated through the creation or enhancement of similar riparian habitat at an approved mitigation site, or by the removal of exotic species from an area of existing similar habitat. The requirement for replacing suitable habitat by either creating new habitat or removing exotic species from existing habitat shall follow the replacement ratios and timing requirements in later mitigation measures. Habitat to be created to mitigate for the loss of riparian habitat shall be designed specifically to replicate the appropriate species mixture and vegetative structure for these species. Existing habitat to be weeded as mitigation for the loss of riparian habitat must be located adjacent to similar habitat that is to be replaced and infested with invasive weeds. The first priority for habitat mitigation for sensitive bird species will be the creation or restoration of habitat rather than weed removal. The final habitat replacement or exotic removal plans for impacts to these types of habitats shall be reviewed by the ACOE and CDFG.<br>s. Beginning 30 or more days prior to the removal of any suitable riparian habitat that will occur during the riparian bird breeding and nesting season of March 15th through September 1st, the applicant shall arrange for weekly bird surveys to detect the above riparian bird species in the habitats to be removed, and any other such habitat within 300 feet of the construction work areas. The surveys shall be conducted by a qualified biologist using CDFG and/or USFWS survey protocols. The surveys shall continue on a weekly basis, with the last survey being conducted no more than 7 days prior to the initiation of construction work. | |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | t. In the event that a special-status species is observed in the habitats to be removed or in other habitats within 300 feet of the construction work areas, the applicant has the option of delaying all construction work in the suitable habitat or within 300 feet of the suitable habitat until after September 1st, or continuing the surveys in order to locate any nests. If an active nest is found, clearing and construction within 300 feet of the nest shall be postponed until the nest is vacated and juveniles have fledged, and when there is no evidence of a second attempt at nesting. Limits of construction to avoid a nest site shall be established in the field with flagging and stakes or construction fencing. Construction personnel shall be instructed on the ecological sensitivity of the area. | |
| | u. Locating and determining the status of a nest shall be performed in accordance with approved procedures by the USSFWS and CDFG. The ACOE and CDFG shall be notified at least 14 days prior to the first scheduled survey and shall have the option of attending. Results of the surveys, including surveys to locate nests, shall be provided to the ACOE and CDFG no later than 5 days prior to construction. The results shall include a description of any nests located and measures to be implemented to avoid nest sites. No surveys will be necessary if the work is completed outside of the riparian bird breeding and nesting season, i.e., from September 1st through March 15th. | |
| | v. Thirty days prior to construction activities in areas of the "upland impact zone" associated with individual NRMP projects, a qualified biologist shall conduct a survey to capture and relocate individual San Diego and California horned lizard, silvery legless lizard, coastal western whiptail, pallid bat, San Diego black-tailed jackrabbit, and San Diego desert woodrat in order to avoid or minimize take of these sensitive species. Individuals shall be relocated to nearby undisturbed areas with suitable habitat. Pre-construction surveys shall only be conducted in areas dominated by Riversidian coastal sage scrub or coastal sage – chaparral scrub or if construction will occur within 300 feet of native upland habitat. Results of the surveys and relocation efforts shall be provided to CDFG in the Annual Mitigation Status Report. Collection and relocation of animals shall only occur with the proper scientific collection and handling permits. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | w. Construction activities shall be limited to the following areas of temporary disturbance: (1) an 85-foot-wide zone that extends into the river from the base of the rip-rap or gunite bank protection where it intercepts the river bottom; (2) 60 feet on either side of the outer edge of a new bridge or bridge to be modified; (3) 50-foot-wide corridor for all utility lines; and (4) 20-foot-wide temporary access ramps and roads to reach construction sites. The locations of these temporary construction sites and the routes of all access roads shall be shown on maps submitted with the Verification Request Letters for individual projects that are submitted to the CDFG and ACOE. Any variation from these limits shall be noted, with a justification for a variation. The construction plans should indicate what type of vegetation, if any, would be temporarily disturbed, and the post-construction activities to facilitate natural revegetation of the temporarily disturbed areas. The boundaries of the construction site and any temporary access roads within the riverbed shall be marked in the field with stakes and flagging. No construction activities, vehicular access, equipment storage, stockpiling, or significant human intrusion shall occur outside the work area and access roads.<br>x. Equipment shall not be operated in areas of ponded or flowing water unless there are no practicable alternative methods to accomplish the construction work, and only after prior approval by the CDFG and the ACOE. Approval shall be acquired by submitting a request to CDFG and ACOE no later than 30 days prior to construction. The request must contain a biological evaluation demonstrating that no sensitive fish, amphibians, and/or reptiles are currently present, or likely to be present during construction, at the construction site or along access roads. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | y. Temporary sediment retention ponds shall be constructed downstream of construction sites that are located in the riverbed under the following circumstances: (1) the construction site contains flowing or ponded water that drains off site into the undisturbed streamflow or ponds, as allowed for certain areas under **Item a.**, above; or (2) streamflow is diverted around the construction site, but the work is occurring in the period November 1st through April 15th when storm flows could inundate the construction site. The sediment ponds shall be constructed of riverbed material and shall prevent sediment-laden water from reaching undisturbed ponds or streamflows. To the extent feasible, ponds shall be located in barren or sandy river bottom areas devoid of existing riparian scrub, riparian woodland, or aquatic habitat. The ponds shall be maintained and repaired after flooding events, and shall be restored to pre-construction grades and substrate conditions within 30 days after construction has ended at that particular site. The location and design of sediment retention ponds shall be included in the Storm Water Pollution Prevention Plan (SWPPP) prepared by the applicant for all construction activities that require a NPDES General Construction Activity Storm Water Permit. | |
| | z. Installation of bridges, culverts, or other structures shall not impair movement of fish and aquatic life. Bottoms of temporary culverts shall be placed at or below channel grade. Bottoms of permanent culverts shall be placed below channel grade. | |
| | aa. Water containing mud, silt, or other pollutants from construction activities shall not be allowed to enter a flowing stream or be placed in locations that may be subject to normal storm flows during periods when storm flows can reasonably be expected to occur. | |
| | bb. Vehicles shall not be driven or equipment operated in areas of ponded or flowing water, or where wetland vegetation, riparian vegetation, or aquatic organisms may be destroyed, except as otherwise provided for in the 404 Permit or 1603 Agreement. | |
| | cc. Silt settling basins, installed during the construction process, shall be located away from areas of ponded or flowing water to prevent discolored, silt-bearing water from reaching areas of ponded or flowing water during normal flow regimes. | |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| 4.6 BIOLOGICAL RESOURCES (continued) | | |
| | dd. If a stream channel has been altered during the construction and/or maintenance operations, its low flow channel shall be returned as nearly as practical to pre-project topographic conditions without creating a possible future bank erosion problem, or a flat wide channel or sluice like area. The gradient of the streambed shall be returned to pre-project grade, to the extent practical, unless it is represents a wetland restoration area.<br>ee. Temporary structures and associated materials not designed to withstand high seasonal flows shall be removed to areas above the high water mark before such flows occur.<br>ff. Staging/storage areas for construction equipment and materials shall be located outside of the ordinary high water mark.<br>gg. Any equipment or vehicles driven and/or operated within or adjacent to the stream shall be checked and maintained daily, to prevent leaks of materials that if introduced to water could be deleterious to aquatic life.<br>hh. Stationary equipment such as motors, pumps, generators, and welders which may be located within the riverbed construction zone shall be positioned over drip pans. No fuel storage tanks shall be allowed in the riverbed.<br>ii. The applicant shall use best efforts to ensure that no debris, bark, slash sawdust, rubbish, cement or concrete or washing thereof, oil, petroleum products, or other organic material from any construction, or associated activity of whatever nature, shall be allowed to enter into, or be placed where it may be washed by rainfall or runoff into, watercourses included in the permit When construction operations are completed, any excess materials or debris shall be removed from the work area.<br>jj. No equipment maintenance shall be done within or near any stream where petroleum products or other pollutants from the equipment may enter these areas with stream flow. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | kk. If water diversions are required to perform work within the Santa Clara River, the applicant shall utilize provisions for the protection of arroyo toad, unarmored three-spine stickleback, arroyo chub, Santa Ana sucker, southwestern pond turtle and two-striped garter snake, including securing appropriate Endangered species permits. Those provisions are as follows:<br>• Prior to initiating construction, the site shall be inspected by a qualified biologist for the presence of the species listed above. The ACOE and the CDFG will be notified of the inspection and will have the option of attending. If either agency is not represented, the biologist will file a written report of the inspection with the agency not in attendance within ten days of completion of the survey. If any of the species listed above are present, the following conditions will apply:<br>– The site shall be surveyed and cleared of the species listed above immediately before the work is to be carried out, immediately before any equipment is moved into or through the stream, and immediately before diverting any stream water. Any species found shall be moved out of the construction area and replaced in the stream in a manner or place to assure their survival.<br>– Blocking nets, or fences with 1/4 inch square mesh, 18 inches high and buried 6 inches, shall be placed upstream and downstream of the work area to assure that none of the species move into the area. | |
| | ll. A qualified biologist will be present at the moment any stream diversion takes place and will patrol the areas, both within and downstream of the work area, to rescue any species stranded by diversion of stream water. If the possibility exists that additional downstream sections of the stream will be dewatered, additional biologists will be available for downstream patrol. This rescue patrol will continue until all dewatered portions of the stream are determined to be cleared. | |
| | mm Once the construction site or a portion of the site and work area boundary has been determined to contain none of the species listed above, the site shall be fenced with construction fencing along the riverside and construction personnel and equipment will not enter the river beyond the fence. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | nn. A water control system will be installed to intercept stream flow upstream of the site and carry it around the site. The system will be completed before turning water into it. The process of turning water into the bypass system shall be done so as to minimize sediment movement.<br>• The Operator will use best efforts to insure that no debris, bark, slash, sawdust, rubbish, cement, concrete, or washings thereof, oil or petroleum products, or other organic material from construction or associated activity will be allowed to enter into or be placed where it may be washed by rainfall or runoff into the river. Sediment management best management practices shall be used during construction.<br>• Impacts to Endangered species may require appropriate Endangered species permits. | |
| | oo. Pilot channels constructed to divert flows around work areas shall be sized to maintain existing water velocities, with wide, shallow channels being utilized. The channel should be kept as small as possible, extending no more than 25 feet upstream and downstream of the work area. Construction of pilot channels should start downstream. Once water is diverted into the new channel, the original channel should be visually inspected and any stranded fish shall be removed and returned to the water downstream of the diversion. Once the diversion is no longer needed, the area shall be restored as closely as practical to its original configuration. | |
| | pp. The use of a pump to divert flows around a work site is also acceptable. The pump must have at least a 1/4-inch screen. Water should be discharged downstream, within 25 feet of the work area. Any dams installed across flowing water for the diversion shall be removed upon completion of construction and the area shall be restored as closely as practical to its original configuration. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | qq. The Operator shall utilize a Maintenance Notification and Emergency Maintenance Notification forms (Exhibits 1 and 2 of the NRMP) to alert the ACOE and the CDFG of work to be performed. In non-emergency situations, the form should be filled out and faxed or mailed to the ACOE and the CDFG at least two weeks in advance of the work. If the work may adversely impact Endangered species, the ACOE, the CDFG and LACDPW shall meet in the field to resolve the issue. LACDPW may contact the ACOE and the CDFG to identify areas of potential Endangered species habitat. If the ACOE and the CDFG believe the work may adversely impact Endangered species or its habitat resources or the LACDPW wishes to consult with the ACOE and the CDFG, a field meeting will be scheduled. At the field meeting, the ACOE and the CDFG will provide information regarding Endangered or Threatened species that could be impacted by the project. If take of an Endangered species will occur, the appropriate Endangered species permits will be required. To the extent that a USFWS Section 7 and a CDFG Section 2081 Memorandum of Agreement have been completed for the species present, the mitigation measures shall be implemented and construction may proceed as outlined in these documents. | |
| | rr. The notification is provided to demonstrate consistency with the policies of the NRMP. In non-emergency situations, the ACOE and the CDFG must respond to the notification within 20 working days if they believe that the work is inconsistent with the NRMP, at which time a field meeting will be scheduled to review the site and determine how the work may proceed. If the ACOE and the CDFG do not respond within 20 working days, the work shall proceed as described in the notification. However, appropriate Endangered species permits will be required for impacts to Endangered species. | |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | b. **Mitigation Measures Recommended by this EIR** | Not Significant |
| | **Resource Management and Monitoring Plan** | |
| | 4.6-2 Prior to issuance of a Grading Permit for the project, the applicant shall obtain the services of a qualified biologist who must, at a minimum, have a degree in botany, biology, wildlife biology or ornithology and experience in developing management plans for the flora and fauna, plant community and wildlife habitats found in the Southern California area, to develop a RMMP to serve as a guideline for managing and monitoring mitigation areas for specific species, plant communities, jurisdictional resource areas, and habitats. The RMMP shall be submitted to the City of Santa Clarita Planning & Building Services at least 30 days prior to issuance of a grading permit for the project, and shall include the following:<br>a. A **Planting Plan**, at a minimum, that lists all appropriate native plants to be included in all revegetation mitigation areas. The planting plan shall be developed by a qualified biologist as approved by the City.<br>b. **Procedures** regarding the removal of non-native vegetation, planting of native vegetation, translocation of trees, planting of container stock, irrigation, and equipment use.<br>c. **Maps** that illustrate the specific location of mitigation areas.<br>d. **Procedures outlining monitoring and maintenance activities** including frequency and timing of monitoring visits, plant maintenance, and irrigation maintenance.<br>e. **Specific criteria** that will specify what goals must be accomplished at each mitigation area before the mitigation is deemed a success.<br>f. **Adaptive Management and Contingency actions** that will specify what actions will be taken in the event success criteria are not met.<br>g. **The source of funding** that will be required to successfully carry out all procedures outlined in the RMMP. | |
| | 4.6-3 Unless directed otherwise by a lead agency, responsible agency, or regulatory agency, the monitoring of results will be maintained for a period of five years. The frequency of monitoring visits may vary by task category, but generally quarterly visits are conducted for the first three years followed by two subsequent annual visits. An annual report shall be produced by the biologist conducting the monitoring activities and will be provided to the lead agency and appropriate regulatory agencies. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | | |
| | | **ACOE Waters of the U.S. and CDFG Streambeds** | Not Significant |
| | 4.6-4 | Newhall shall prepare an amendment or variance to the NRMP and mitigate in accordance with the above requirements. | |
| | | **Special-Status Plant Species** | Not Significant |
| | | *Parry's larkspur, Slender and Plummer's mariposa lilies* | |
| | 4.6-5 | To minimize direct loss of Parry's larkspur, slender and Plummer's mariposa lilies in areas subject to disturbance, additional field surveys to determine amount of area covered by these species and approximate densities shall be conducted during the appropriate blooming period for these species prior to site preparation and/or grading activities in areas potentially supporting this species. Locations of individual plants or plant populations shall be appropriately flagged and (1) seeds from a representative mix of individual plants shall be collected and sown in appropriate habitats, or on cut slopes, and (2) the bulbs shall be harvested and transplanted to areas of appropriate habitat which are not subject to further disturbance. The goal will be to produce replacement populations of in-kind plants reaching maturity, at a ratio of 1:1 with respect to the number and density of plants (estimated) to be lost. The areas to be preserved and maintained as open space within the Riverpark project site contain habitat suitable to support these species. All seed collecting, planting, and transplanting procedures shall be identified in the RMMP and appropriate management, monitoring, success criteria, and adaptive management guidelines for the mitigation of impacts to these species shall also be identified. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | *Oak Trees* | |
| | 4.6-6 While the majority of oak trees on the site will be retained in place, three live trees will be removed and 12 will be relocated. Appropriate approvals shall be obtained prior to oak trees being removed, subject to the Oak Tree Preservation Ordinance (Ordinance 89-1) and the City of Santa Clarita Oak Tree Preservation and Maintenance Guidelines. Prior to grading, oak trees near construction/grading areas that will not be removed will be protected during the grading and construction phases of the project by appropriate fencing that extends five feet beyond the tree canopy's dripline, or 15 feet from the trunk, whichever is greater. | Not Significant |
| | 4.6-7 Additional specific mitigation measures are described in detail in the Oak Tree Report produced by Tree Life Concern, Inc. (**Appendix 4.6**) and listed below. The mitigation measures described in this report are supported by the City's Oak Tree Specialist and exceed the requirements of the City of Santa Clarita Tree Ordinance.<br>• Equipment damage to the limbs, trunks and roots must be avoided. Even slight trunk injuries can result in long-term, life threatening pathogenic maladies. No storage of equipment or debris within the Protective Zone (dripline plus 5') will be allowed. No dumping of construction wastewater i.e., paint, stucco, concrete, clean-up, etc. within Protective Zones, Generally, fencing shall be placed at the Protective Zone of any oak or groups of oaks within 50' of proposed construction activity. Protective Fencing must remain in place during construction projects and shall not be moved or removed without prior written approval from the Department of Community Development under the direct supervision of the Project Consulting Arborist.<br>• Protective Fencing shall be at least 4' in height with a visible sign attached at 50' intervals that reads: "WARNING - THIS FENCE IS FOR THE PROTECTION OF THIS TREE AND SHALL NOT BE REMOVED OR RELOCATED WITHOUT WRITTEN AUTHORIZATION FROM THE CITY OF SANTA CLARITA COMMUNITY DEVELOPMENT DEPARTMENT". | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | • If possible, complete pruning of the larger California Live or Valley oaks, is recommended for health and weight reduction (inspect for occupied woodpecker nests prior to removal of larger dead snags). Any cuts over 2' diameter would require a Pruning Permit from the City. After pruning, the installation of support cables to prevent future main crotch failures is recommended (refer to the Summary of Field Inspection for specific tree and cable numbers). All cables should be a minimum of 5/16" diameter EHS (Extra High Strength) and attached with 5/8" diameter, galvanized thru-bolts. Heavy-duty 3/8" thimbles are to be utilized at each attachment point. These recommendations are presented for consideration by the City, current and/or future property owners.<br>• Care should be taken to avoid placing any sprinklers within watering distance to the trunk of an oak tree. Generally, sprinklers should not reach within 15' of a mature oak trunk. Grass or ground covers must never be planted next to the trunks. Too much moisture near the base of an oak is generally believed to be their leading cause of death in residential settings. Oak Root Fungus is the result of over-watering. Oak trees survive and thrive on annual rainfall alone and generally do not need supplemental irrigation except during periods of drought. Watering should take place at or near the dripline. Landscape plans should leave the area within the dripline of an oak tree in a native or natural setting.<br>• Care must be taken to limit grade changes near the trunk areas. The grade should not be lowered or raised around the trunks of trees. This can lead to plant stress from oxygen deprivation or Oak Root Fungus at the root collar.<br>• Mitigation for the tree removals/relocations includes the dedication of a 24-acre property with oak tree habitat. This property is directly adjacent to the 4.25-acre active neighborhood park and contains a majority of the oak trees on the project site. The proposed mitigation (dedication of 24 acres of oak habitat open space and the transplanting of oak trees on-site including the costs associated with the corresponding five-year maintenance plan of said trees) for oak tree impacts is consistent with the provisions of the City's Oak Tree Preservation Ordinance. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| 4.6 BIOLOGICAL RESOURCES (continued) | | |
| | • Protective fencing shall be installed around all oaks not listed for removal. Place protective fencing at the PZ as shown on the TLM. The fencing can be re-positioned as needed to allow for grading near the oaks listed as "impacted". The project arborist must be present during the fence placement. Final fencing locations shall be inspected by the City prior to the commencement of development activities. Regular inspections of this fencing shall occur during site development.<br>• An Oak Tree Information Packet including the City of Santa Clarita Oak Tree Protection and Preservation Guidelines must be available on-site during construction. The property owner and contractor should be familiar with the contents of these documents.<br>• Vehicle travel along dirt roadways to and from the site may create a heavy coating of dust on the foliage of nearby oaks. These oaks should be hosed off periodically during construction activities.<br>• All work performed within the Protective Zone (dripline plus 5') of any oak shall be accomplished by utilizing hand tools only and must be 'monitored' by the project's Oak Tree Consultant.<br>• All roots over 1.5" diameter will be clean cut at a 45 degree angle and treated by the Consulting Arborist.<br>• No oaks outside the property line are to be impacted by this construction project.<br>• The leaf-litter build-up under the canopies of the oaks on this site is ideal for healthy tree growth and root development. Do not alter or remove if possible. A 3-inch layer of mulch may be advisable in settings where leaf-litter has been lost.<br>• Do not remove the aluminum tags numbering each oak on this site<br>• No construction materials are to be stored or discarded within the PZ of any oak. Rinse water, concrete residue, liquid contaminates (paint, thinners, gasoline, oils, etc.) of any type shall not be deposited in any form at the base of an oak.<br>• No vehicles shall be parked within the PZ of an oak. No construction vehicles are to be parked under the shade (within the PZ) of an oak. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | **Oak Transplantation**<br><br>The oak trees listed for transplanting shall be professionally "boxed" and relocated on-site to the designated "storage area" (see TLM). A qualified transplant company shall perform the relocations (it is anticipated that Valley Crest Tree Company will be performing the relocations). To enhance the success of each tree for long-term survival the relocations will be monitored by the Project Arborist. The size of box for each tree will be determined by the Arborist and Valley Crest representative (see chart below). Consideration will be given to the buttress spread, as well as the trunk diameter. Generally, the larger the box the greater the probability of success. In every case where a decision is to be made between a smaller size box and a larger box, i.e., I go" or 192" box, the box of choice will be the 192" box.<br><br>Under the direction of the Project Arborist, side-boxing/root-pruning operations shall take place during the months of November through January. These trees will then be maintained in situ for a 90-day period prior to bottom-board installation and relocation to the "storage site".<br><br>A "storage site" has been designated (see TLM) with a permanent water supply, which will be accessible to each boxed tree.<br><br>The Project Arborist (in conjunction with the relocation company) will determine if and when fungicides, fertilizer or soil amendments are needed. Each tree will be monitored for any condition that may require a specific treatment to enhance survivability before, during and after relocation.<br><br>Prior to side-boxing and root pruning the soil moisture content must be sufficient to maintain the rootball intact during this process.<br><br>Each oak should be lightly pruned at this point to remove deadwood, stubs, broken limbs, crossing limbs or for clearance purposes. The pruning will be monitored.<br><br>The excavation process will first begin with a back-hoe. As roots are encountered the back-hoe will be removed and roots 2" or larger will be hand excavated and clean-cut with a handsaw.<br><br>The exposed cuts will be treated with a Bordeaux linseed oil solution to help prevent desiccation. All roots shall be clean cut with pruning shears or by handsaw. Root balls that are exposed to full sun will be tarped until the side-box wall is installed. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | After side-boxing/root-pruning operations the trees will remain in place for approximately 90 days before the bottom boards are installed.<br><br>The boxed trees will be hoisted by the box itself (not by the trunk) and carried to the storage area.<br><br>The orientation of each oak (north, south, east, west) will be carefully maintained during the storage process. The project arborist will mark each box for proper direction while in storage. This is important to prevent damage from sunburn.<br><br>Valley Crest shall guy-wire each tree as needed into the box and/or into the ground as needed. The storage area is notoriously windy and extra attention will be paid to securing the trees until planting. The guy-wires will be placed through hose-sections where they are in contact with the tree.<br><br>When planting the oaks, the planter-hole (pit) location will be partially filled with loosened native soil. The size of the hole will be 2' larger than the box size. If drainage is determined to be a concern, PVC drain tubes will be installed in a rectangular fashion with breather ports attached at four locations. The bottom of the pit will be filled with 8" of gravel and a layer of permeable soil-cloth will be placed over the gravel.<br><br>An 8" layer of native soil will then be placed over the cloth and the tree install backfilled. This will allow for monitoring any possible water pooling at the base of each tree. Unamended native soil will be utilized for the backfill unless a soil analysis indicates that amendments will be required.<br><br>A soil analysis will be performed at the planting site 30 days prior to relocation. The backfill soil will be compacted to normal (native-soil compaction).<br><br>The height of the root ball is critically important in the long-term survival of a transplanted oak. Each rootball will be placed at least 6" above existing grade. This will allow for settling and ensure that water does pool at the root collar.<br><br>Soil watering-basins will be constructed to properly irrigate the entire rootball of each tree. The trees will be monitored by relocation company and the Project Arborist on a weekly basis to determine current condition and maintenance requirements. | |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | 4.6-8 All revegetation, restoration, and enhancement measures within mixed oak woodlands shall be documented in the Resource Management and Monitoring Plan and shall include, at a minimum, the following: (1) the location of the planting/revegetation areas (to be coordinated with the City; (2) the species of oaks and other plant species to be planted within the protected zone of the oaks; (3) planting procedures; (4) a schedule and action plan to maintain the plantings; and (5) a list of criteria by which to measure success of the plantings, as well as contingency measures if the plantings are not successful. | |
| Mitigation measures to avoid take of state- and federally-listed Threatened and/or Endangered species have been identified in the NRMP EIS/EIR and in the Section 1603 Streambed Alteration Agreement issued by CDFG for the NRMP. A detailed program of mitigation measures is set forth in the NRMP Section 1603 Streambed Alteration Agreement and a blanket Section 7 Endangered species permit has been issued in conjunction with the NRMP. In addition, compliance with the California Endangered Species Act will occur, as applicable. | **Special-Status Wildlife**<br>Mitigation measures included in the NRMP EIS/EIR and Section 1603 authorization include the following:<br>• Surveys and site inspections for the least Bell's vireo (vireo) and unarmored three-spine stickleback (UTS) by qualified biologists;<br>• Installation of blocking nets as specified by FWS for the UTS;<br>• Specific stream diversion practices utilizing qualified biologists for the UTS; and<br>• Limitations on construction activities during the nesting season near occupied habitat for the vireo. | Not Significant |
| | **Increased Human and Domestic Animal Presence** | |
| | 4.6-9 Pets and other domestic animals shall be prohibited with fencing and signage from the open space areas and in any revegetation areas on the project site unless restrained by leash and only in designated areas. | Not Significant |
| | 4.6-10 Fencing of sufficient height and design (i.e., ranch-rail) shall be constructed between the edge of the fuel modification zone and the river corridor to deter humans and domestic animals from entering open space habitat areas. | |
| | 4.6-11 Native shrubs such as laurel sumac, California coffeeberry, toyon, and coast prickly-pear shall be planted along the fence to further deter access. Final fence design shall be approved by and the City Planning and Building Services Department. | |

## Table ES-1 (continued)
## Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | 4.6-12 Human access into the open space areas shall only occur in designated locations (i.e., existing and future trails). All motorized vehicles are prohibited from entering the preserved natural open space areas with the exception of emergency or maintenance vehicles. Applicant shall post signage reflecting the above requirement. | |
| | 4.6-13 Prohibitions against human, domestic animal, and motorized vehicle use in preserved natural open space areas shall be established by the covenants conditions and restrictions (CC&Rs) recorded with the City Planning and Building Services Department. | |
| | 4.6-14 Interpretative signs shall be constructed and placed in appropriate areas, as determined by the City Planning and Building Services Department that explain the sensitivity of natural habitats and the need to minimize impacts on these natural areas. The signs will state that they are entering a protected natural area and that all pedestrians must remain on designated trails, all pets are to be restrained on a leash, and that it is illegal to harm, remove, and/or collect native plants and animals. The project applicant shall be responsible for installation of interpretive signs and fencing. | |
| | **Lighting and Glare** | |
| | 4.6-15 All street, residential, and parking lot lighting shall be downcast luminaries or directional lighting with light patterns directed away from natural areas. Covenants, Codes and Restrictions (CC&Rs) shall require the exterior lighting within the residential area be limited to low voltage. | Not Significant |

Table ES-1 (continued)
Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | **Construction-Related Activities** | |
| | The following measures shall be implemented to minimize impacts on remaining biological resources on the site as a result of construction and grading activities and to ensure that potential impacts on these resources will remain less than significant. | Not Significant |
| | 4.6-16 A qualified biologist, as determined by the City of Santa Clarita, shall be retained as a construction monitor to ensure that incidental construction impacts on biological resources are avoided, or minimized, and to conduct pre-grading field surveys for special-status plant and wildlife species that may be destroyed as a result of construction and/or site preparation activities. Responsibilities of the construction monitor include the following:<br>• The construction monitor shall attend pre-grade meetings to ensure that timing/location of construction activities do not conflict with mitigation requirements (e.g., seasonal surveys for plants and wildlife).<br>• Mark/flag the construction area in the field with the contractor in accordance with the final approved grading plan. Haul roads and access roads shall only be sited within the grading areas analyzed in the project EIR.<br>• Supervise cordoning of preserved natural areas that lie outside grading areas identified in the project EIR (e.g., with temporary fence posts and colored rope).<br>• Conduct a field review of the staking (to be set by the surveyor) designating the limits of all construction activity. Any construction activity areas immediately adjacent to riparian areas or other special-status resources should be flagged or temporarily fenced by the monitor, at his/her discretion.<br>• Conduct meetings with the contractor and other key construction personnel describing the importance of restricting work to designated areas. The monitor should also discuss procedures for minimizing harm/harassment of wildlife encountered during construction.<br>• Periodically visit the site during construction to coordinate and monitor compliance with the above provisions. | |
| | 4.6-17 Construction personnel shall be prohibited from entry into areas outside the designated construction area, except for necessary construction related activities, such as surveying. All such construction activities shall be coordinated with the construction monitor. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.6 BIOLOGICAL RESOURCES (continued)** | | |
| | 4.6-18 Standard dust control measures shall be implemented to reduce impacts on nearby plants and wildlife. This includes replacing ground cover in disturbed areas as quickly as possible; water active sites at least twice daily; suspend all excavating and grading operations when wind speeds (as instantaneous gusts) exceed 25 mph; and restricting traffic speeds on all unpaved roads to 15 mph or less in areas within 200 feet of vegetation. | |
| | 4.6-19 Upon completion of construction, the contractor shall be held responsible to restore any haul roads and access roads that are outside of approved grading limits. This restoration shall be done in consultation with the construction monitor. | |
| | In addition, impacts to biological resources as a result of construction and grading activities will be mitigated by implementation of NRMP **Mitigation Measures 4.6-1w.** through **uu.**, above. | |
| **4.7 LAND USE** | | |
| The project applicant is requesting a General Plan Amendment and Zone Change to designate the 695.4-acre site as 692.4 acres of RM (PD) and 3.0 acres of CC (PD). The project applicant is requesting 439 single-family and 744 multi-family residential lots adjacent to and in close proximity to Newhall Ranch Road and Santa Clarita Parkway. Two ridgelines classified by the City as secondary traverse a portion of the project site. The project applicant is providing an innovative application to the Planning Commission/City Council for approval of uses on portions of these secondary ridgelines. It can be concluded that the project satisfies the intent of both the ridgeline protection and hillside development standards and will not result in a significant land use impact. | The proposed project is consistent with the applicable goals and policies of the General Plan, consequently there would be no impacts and no mitigation is required. | Not Significant |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| 4.8 WATER SERVICES | | |
| Using water demand factors provided by SCWD, the proposed project would consume approximately 697 AFY.<br><br>Existing water demand in the Santa Clarita Valley is approximately 77,998 AFY in average years (this figure accounts for a dry year increase in water demand in 2002 of approximately 10 percent). Of this demand, approximately 68,023 acre feet is related to urban or developed areas and approximately 15,278 acre feet is related to other uses in the Santa Clarita Valley, including agricultural uses. When combined with the Riverpark water demand of 697 AFY, the total water demand in the Santa Clarita Valley would be approximately 77,998 acre feet if Riverpark were completely built out today.<br><br>Existing supplies exceed the project demand, in conjunction with existing demand in the Santa Clarita Valley. Existing water supplies exceed demand by 2,283 to 10,553 AFY in dry years and by 25,775 AFY in an average/normal year after adding the proposed project to existing demands; therefore, no significant near-term water supply impacts are anticipated. | No mitigation is required as there are no significant impacts. | Not Significant |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.8.1 WATER QUALITY** | **a.** | **Mitigation Measures Already Incorporated Into the Project** | Not Significant |
| The project is expected to have a less than significant impact on surface water quality, as discussed above, and accordingly, no water quality mitigation measures are required under CEQA. Nonetheless, the project proponent proposes to include the following measures to improve further the quality of storm water runoff from the project site.<br><br>The project would generate pollutants typical of urban residential and small commercial areas both during construction, and after the site is built out and occupied. In addition, the existing condition of the Santa Clara River, and the current water quality standards applicable to it give rise to water quality concerns. Primary pollutants of concern include minerals/salts, total suspended solids, nutrients, trace metals, pathogens, hydrocarbons, pesticides, and other toxics. Constituents for which sufficient data was available were analyzed quantitatively using a water quality model created to address the project's features. Taking into account the project's non-structural and structural (treatment) best management practices (BMPs) design features, and evaluating the identified pollutants of concern, the following analysis concludes that project water quality impacts would be less than significant. The project would meet all applicable regional and local water quality requirements of the State Water Resources Control Board, the Regional Water Quality Control Board, Los Angeles Region, the National Pollutant Discharge Elimination System, the County of Los Angeles and the City of Santa Clarita during both construction and operation of the project. | 4.8.1-1 | To reduce pollution from impacts from the "first flush" runoff, a series of pipes and outlets would be constructed pursuant to Los Angeles County Department of Public Works requirements to intercept first flush runoff from paved developed areas and channel it to above ground and/or subsurface water quality control basins. | |
| | 4.8.1-2 | The project is required to comply with the RWQCBLAR Municipal Permit (General MS4 Permit) Order No. 01-182, NPDES No. CAS004001 (adopted December 13, 2001) to reduce the discharge of pollutants to the maximum extent practicable. | |
| | 4.8.1-3 | To treat storm water, two water quality detention basins, a grassy swale, and hydrodynamic separator systems would be constructed. | |
| | 4.8.1-4 | Post-construction structural or treatment control BMPs to minimize or prevent storm water pollutants from discharging into the Santa Clara River shall, at minimum, include:<br><br>• water quality detention basins;<br>• a grassy swale; and<br>• hydrodynamic separator systems, such as Continuous Deflective Separator (CDS) units.<br><br>Additional equivalent BMPs that could alternatively be implemented at the project site include:<br><br>• catch basin inserts;<br>• storm water filters; and<br>• storm water clarifiers. | |
| | | The project is expected to have a less than significant impact on surface water quality, as discussed above, and accordingly, no water quality mitigation measures are required under CEQA. Nonetheless, the project proponent proposes to include the following measures to improve further the quality of storm water runoff from the project site. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.8.1 WATER QUALITY (continued)** | | |
| | **b. Mitigation Measures Proposed By This EIR** | |
| | **Construction Impacts** | |
| | 4.8.1-5 All necessary permits, agreements or letters of exemption from the U.S. Army Corps of Engineers, U.S. Fish and Wildlife Service, California Department of Fish and Game, and/or the Regional Water Quality Control Board for project-related development are to be obtained prior to start of soil-disturbing activities. | |
| | 4.8.1-6 Prior to start of soil-disturbing activities at the site, a Notice of Intent (NOI) and Storm Water Pollution Prevention Plan (SWPPP) shall be prepared in accordance with and in order to partially fulfill the California State Water Resources Control Board Order No. 99-08-DWQ, National Pollutant Discharge Elimination System (NPDES) General Permit No. CAS000002 (General Construction Permit). The SWPPP shall meet the applicable provisions of Sections 301 and 402 of the CWA by requiring controls of pollutant discharges that utilize best available technology economically achievable (BAT) and best conventional pollutant control technology (BCT) to reduce pollutants. The SWPPP shall be certified the City of Santa Clarita in accordance with the signatory requirements of the General Construction Permit and implemented concurrently with commencement of the soil-disturbing activity. | |
| | 4.8.1-7 Per the April 26, 2001 modification to the General Construction Permit, a contingency "Sampling and Analysis Plan" shall be developed in the event that the BMPs implemented at the construction site fail to prevent non-visible pollutants from discharging from the site. BMPs shall be inspected prior to storm events, every 24 hours during extended events, and after the storm events to ensure proper function of the BMPs and to identify necessary repairs in a timely manner. A record of the inspections and repairs shall be documented in the SWPPP. | |
| | 4.8.1-8 Following the completion of the construction project and when the site has been stabilized, a Notice of Termination shall be filed with the RWQCBLAR. | |
| | 4.8.1-9 During construction, delineate and flag the smallest site disturbance area possible to minimize soil compaction and restricting temporary storage of construction equipment in these areas, as appropriate. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.8.1 WATER QUALITY (continued)** | | |
| | **Operational Impacts** | |
| | 4.8.1-10 For treatment efficiency, the biofiltration swale shall maximize length and minimize depths. Slopes of the swale shall also be kept to between 2 and 5 percent to prevent scouring. | |
| | 4.8.1-11 The homeowners' association or the City of Santa Clarita shall be responsible for the operation and maintenance of any detention basins on the site, which include:<br>• Dispersion of alluvial sediment deposition at inlet structures, thus limiting the extended localized ponding of water.<br>• Periodic sediment removal to ensure adequate storage and treatment volume.<br>• Monitoring of the basin to ensure it is completely and properly drained.<br>• Outlet riser cleaning.<br>• Vegetation management to prevent marsh vegetation from taking hold, and to limit the growth of habitat for disease-carrying fauna.<br>• Removal of graffiti, litter, vegetative and other debris.<br>• Preventative maintenance on monitoring equipment.<br>• Vegetative stabilization of eroding banks. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.8.1 WATER QUALITY (continued)** | | |
| | 4.8.1-12 The homeowners' association or the City of Santa Clarita shall be responsible for the maintenance and monitoring of any biofiltration swales on the site, which include:<br>• Vegetation management to maintain adequate hydraulic functioning and to limit habitat for disease-carrying animals.<br>• Animal and vector control.<br>• Periodic sediment removal to optimize performance.<br>• Trash, debris, grass trimmings, tree prunings, and leaf collection and removal to prevent obstruction.<br>• Removal of standing water, which may contribute to the development of aquatic plant communities or mosquito breeding areas.<br>• Erosion and structural maintenance to prevent the loss of soil and maintain the performance of the swale.<br>Although maintenance requirements vary greatly depending on the particular model and manufacturer, biofiltration swales shall be maintained quarterly to yearly for clean-outs. Cleaning after a storm event shall be required. Inspection will be required to make certain that the unit is operating correctly and to make any repairs. | |
| | 4.8.1-13 The homeowners' association or the City of Santa Clarita shall be responsible for the operation and maintenance of any storm water filters on the site, to include:<br>• Providing adequate access for inspection and maintenance.<br>• Removal of accumulated trash, paper and debris.<br>• Corrective maintenance including removal and replacement of top layers of media.<br>• Complete replacement of filter media every 3 to 5 years.<br>• Periodic removal of vegetative growth. | |
| | 4.8.1-14 The homeowners' association or the City of Santa Clarita shall be responsible for the operation and maintenance of any storm water clarifiers on the site, which include:<br>• Inspection prior to the beginning of the storm season.<br>• Regular inspection following storm events.<br>• Removal of accumulated sediment, trash and debris. | |

## Table ES-1 (continued)
## Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.8.1 WATER QUALITY (continued)** | | |
| | 4.8.1-15 Monthly street sweeping shall occur in high traffic areas and annual or semi-annual street sweeping shall occur in areas with low rates of traffic and little pedestrian use. The homeowners' association or private property owner shall be responsible for sweeping the private streets. | |
| | 4.8.1-16 "Low-impact" vegetation shall be planted in common areas. This vegetation requires minimal irrigation, fertilizing and pest control, and could include native and/or non-invasive plants. | |
| | 4.8.1-17 An education program shall be developed and implemented for the residents and landscape contractors regarding activities and practices that could affect water quality, such as carpet and other cleaners that are not properly disposed of, residential car washing, and animal waste management, such as the importance of cleaning up after pets and not feeding wild animals, such as pigeons, seagulls, ducks and geese. Community car washes shall only take place in areas that are drained to the sanitary sewer system. Pet bags would be provided along trails. | |
| | 4.8.1-18 On-site features that attract wild animals shall be kept to a minimum in order to minimize pathogens in the storm system. | |
| | 4.8.1-19 Pesticide applications shall be managed through educational and other source control efforts, including the installation of efficient landscape irrigation systems in common areas and the development of guidance on applying these types of chemicals for contractors maintaining landscape areas. Examples of material which may be used for education may include educational pamphlets currently available through the City of Santa Clarita, LA County and/or other sources (i.e., http://www.americanoceans.org/runoff/epa-bro.htm). Because of the concerns regarding indicators of human pathogens, education programs shall emphasize animal waste management, such as the importance of cleaning up after pets and not feeding wild animals, such as pigeons, seagulls, ducks and geese. The project applicant shall create and distribute these pamphlets to landscape contractors prior to on-site planting. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.8.1 WATER QUALITY (continued)** | | |
| | 4.8.1-20 The project applicant shall prepare an herbicide/pesticide program to be utilized by landscaping contractors on commonly owned landscaped areas. This program shall include requirements to minimize the use of herbicides and pesticides in these landscaped areas and shall be prepared and in place prior on-site planting. | |
| **4.9 SOLID WASTE** | | |
| Upon project buildout and assuming no solid wastes from the proposed project would be recycled (a worst-case scenario), the project would generate a total of 10,203 pounds of solid waste per day. This is equivalent to approximately 1,862 tons per year. Although the project would generate approximately 1,862 tons of waste per year, it can be assumed that the project will meet the current recycling goals of the community and, therefore, generate 931 tons per year. This is based on the current City diversion rate of 50 percent of waste disposal. The project may also generate household-type hazardous wastes. | **a. Mitigation Measures Already Incorporated into the Project** | |
| | 4.9-1 Solid waste collection/recycling areas are to be compatible with nearby structures, secure, protected against adverse environmental conditions, clearly marked, adequate in capacity, number and distribution, and contain a sufficient number of bins, to serve the recycling needs of the development. (Model Ordinance) | Significant |
| | 4.9-2 Design and construct collection/recycling areas to accommodate front-loader packing trucks, including maneuvering room. (Model Ordinance) | |
| | 4.9-3 Design and construct driveways and/or travel aisles with adequate width and maneuverability space for unobstructed garbage collection, trash container storage and vehicle access and clearance. (Model Ordinance) | |
| | 4.9-4 Post signs at all access points of the recycling areas that clearly identify all recycling and solid waste collection and loading areas and the materials accepted therein. (Model Ordinance) | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.9 SOLID WASTE (continued)** | | |
| The project's 1,862 tons per year (without recycling) would represent 0.47 percent of this Valley-wide total. Land suitable for landfill development or expansion is quantitatively finite and limited due to numerous environmental, regulatory and political constraints. This is not to say, though, that alternative solid waste disposal technologies that could substantially reduce landfill disposal will not be developed and legislatively approved in the future; given the market forces that drive the solid waste industry, it seems reasonable to assume they will. However, until other disposal alternatives that will be adequate to serve existing and future uses for the foreseeable future are found and because landfill space is a finite resource project, the potential project and cumulative solid and hazardous waste impacts are considered unavoidably significant. | **b. Mitigation Measures proposed by This EIR** | |
| | **General Provisions** | |
| | 4.9-5 Locate recycling/separation areas in close proximity to dumpsters for non-recyclables, elevators, loading docks, and primary internal and external access points. | |
| | 4.9-6 Locate recycling/separation areas to not be in conflict with any applicable Federal, State or local laws relating to fire, building, access, transportation, circulation, or safety. | |
| | 4.9-7 Locate recycling/separation areas so they are convenient for those persons who deposit, collect, and load the recyclable materials. | |
| | 4.9-8 Place recycling containers/bins so that they do not block access to each other. | |
| | 4.9-9 Reduce yard waste on the project site through the use of xeriscape techniques and the use of drought-tolerant and native vegetation in common area landscaping wherever possible. | |
| | 4.9-10 For commercial developments and residential buildings having five or more living units, no refuse collection or recycling areas are to be located between a street and the front of a building. | |
| | 4.9-11 Install on-site trash compactors for non-recyclables in all restaurants/food services areas. | |
| | 4.9-12 If possible, kitchen, garage or garden design shall accommodate trash and recyclable components to assist in the City's recycling efforts. This includes a design to accommodate a minimum of three 90-gallon containers in locations allowable under the CC&Rs. | |
| | 4.9-13 First-time buyers shall receive educational material on the City's waste management efforts. Educational material shall be passed to consecutive buyers using the CC&Rs. | |
| | 4.9-14 The applicant shall comply with all applicable state and Los Angeles County regulations and procedures for the use, collection and disposal of solid and hazardous wastes. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.9 SOLID WASTE (continued)** | | |
| | **Construction Impacts** | |
| | 4.9-15 Place recycling bins for glass, metals, paper, wood, plastic, greenwastes, and cardboard on construction sites to ensure their use by construction workers to then be trucked to recycling/processing facilities. | |
| | 4.9-16 In construction specification and bid packages, require building materials made of recycled materials, to the extent possible. | |
| **4.10 EDUCATION** | | |
| It is estimated that the project would generate 288 new elementary students, 71 new junior high students and 115 new high school students in the Saugus and Hart districts at buildout. The Saugus District is operating within its total capacity. Student enrollment in the Hart District exceeds available capacity even with the use of portable classrooms.<br><br>Project applicant compliance with the School Facilities Funding Agreement Between the Saugus Union School District and the Newhall Land and Farming Company (February 1997) and the School Facilities Funding Agreement Between the William S. Hart Union High School District and the Newhall Land and Farming Company (October 1998) was designed to mitigate all project impacts to these districts to less than significant levels. Because the school districts agree that compliance with the school district agreement will mitigate all project impacts on school facilities, the Riverpark project would result in no significant impact on these districts, and no additional project mitigation is required.<br><br>Cumulative student generation under the DMS Build-Out Scenario and under the Santa Clarita Valley Build-Out Scenario cannot be accommodated by existing or planned facilities within the school facilities that serve the Valley and cumulative impacts on the districts would be significant. Compliance, as appropriate, with existing School Facilities Funding Agreements and/or other mechanisms (e.g., SB 50, the Valley-Wide Joint Fee Resolution, and/or new school facilities funding agreements) would reduce cumulative development impacts on the school districts to below a level of significance and no unavoidable significant cumulative impacts to educational services are anticipated. | No mitigation required as agreements with school districts has already been reached. | Not Significant |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.11 LIBRARY SERVICES** | | | |
| Library services for the proposed project and the Santa Clarita Valley area are provided by the County of Los Angeles Public Library system. The City of Santa Clarita contracts with the County of Los Angeles for public library services. The Santa Clarita Valley area is served by three County libraries (Valencia, Newhall, and Canyon Country Jo Anne Darcy) and a mobile library service. Existing library space in the Santa Clarita Valley does not meet the County Public Libraries library planning standards.<br><br>Development of the proposed project would result in increased demands on library facilities and would, according to County Library planning standards, create a demand for 1,789 gross square feet of library space and 7,152 items (books, periodicals, audio cassettes, videos, etc.). Recommended payment of the City adopted library impact fee, $640.00 per new residential dwelling unit as of November 2002, for new library construction and book purchases would reduce this impact to a less than significant level. In addition, revenues collected by the City of Santa Clarita over the course of buildout of the project would fund library service in the Santa Clarita Valley and also reduce impacts. | a. | **Mitigation Measures Already Incorporated into the Project** | |
| | 4.11-1 | The applicant shall pay the current library fee ($640.00 per residential unit as of November 2002) to the City of Santa Clarita to offset the demand for library items and building square footage generated by the proposed project or whatever fee is established by either the City or County at the time of building permit issuance, whichever is higher. The library mitigation payment shall be made on a building permit by building permit basis. This current per unit mitigation fee of $640.00 would generate at least a total of $757,120.00 in library facility fees if all units proposed were built, and would fund new library space and materials which would be needed to serve the project. | Not Significant |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.12 PARKS AND RECREATION** | | |
| The project incorporates a 29-acre active/passive park, which will have direct access to the City's Santa Clara River River Trail, a portion of which is proposed for construction as a part of this project. Except for intrusion by the future Santa Clarita Parkway Bridge, the alignment of Newhall Ranch Road (including the Newhall Ranch Road/Golden Valley Road Bridge) and a water quality basin, the entire 300 acres of river area within the project boundaries (defined by a 404/1603 jurisdictional delineation per the already approved Natural River Management Plan) will remain in a natural state (except for bank stabilization). Measured under the identified significance threshold, the Riverpark project is in compliance with Quimby Act parkland standards and would not result in significant unavoidable impacts to local parks and recreation facilities.<br><br>Implementation of cumulative projects would incrementally increase demand for local active park facilities in an area where such facilities are already below locally adopted standards. However, the proposed project will meet and exceed the City and Quimby Act local parkland standards with a combination of a public park and private recreational facilities. Furthermore, future development projects would also be subject to the City and Quimby Act requirements, which would mitigate the demands associated with each future project. Given this, no significant cumulative parkland impacts are expected to occur. | **a. Mitigation Measures Already Incorporated into the Project**<br><br>4.12-1 Development of the Riverpark project will provide the following parks and open areas:<br>• a 29-acre active/passive park including 4.5 acres of improved park area, which will be dedicated to the City;<br>• three private recreation lots totaling 1.3 acres; and<br>• 440-acres of dedicated open space, 330.8 acres of which include the Santa Clara River Area.<br><br>4.12-2 The applicant will meet City parkland requirements by providing either the dedication of land, payment of in-lieu fees, or construction of park amenities, or a combination of the three as approved by the Director of Parks, Recreation and Community Services, prior to issuance of building permits.<br><br>**b. Mitigation Measures Recommended by the EIR**<br><br>The provision of parks and open areas for credit pursuant to the City Standards and the Quimby Act will occur as individual subdivision maps are processed in accordance with standard City practice.<br><br>4.12-3 Developer shall construct all trails and shall be in accordance with the City of Santa Clarita Department of Parks and Recreation trail system standards.<br><br>4.12-4 The City of Santa Clarita shall receive ownership and/or easements of existing maintenance roads/trails and open space prior to easements provided to the Los Angeles County Flood Control District or others. | Not Significant |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.13 FIRE SERVICES** | | | |
| Project implementation would result in an increase in calls for fire protection services received by the County of Los Angeles Fire Station 111. As proposed, the project would have an impact on the current level of local fire protection services; however, proposed mitigation measures would reduce impacts to a level of insignificance. | **a.** | **Mitigation Measures Already Incorporated into the Project** | |
| | 4.13-1 | All proposed development on the site must comply with applicable state, City and County code and ordinance requirements. | Not Significant |
| | **b.** | **Mitigation Measures Recommended by This EIR** | |
| | 4.13-2 | Concurrent with the issuance of building permits, the applicant shall either participate in the Developer Fee Program or make an in-lieu donation to the satisfaction of the County of Los Angeles Fire Department. | |
| | 4.13-3 | The project shall prepare a Fuel Modification Plan, landscape plan and irrigation plan as required for projects located with a Very High Fire Hazard Severity Zone. The Fuel Modification Plan shall be submitted and approved by the County Fire Department prior to final map clearance. The Fuel Modification Plan shall depict a fuel modification zone in conformance with the Fuel Modification Ordinance in effect at the time of subdivision. The fuel modification plan shall not conflict with the revegetation plan as directed in **Section 4.6, Biological Resources.** | |
| | 4.13-4 | The project shall provide water mains, fire hydrants and fire flows as required by the County of Los Angeles Fire Department, for all land shown on the map that shall be recorded. | |
| | 4.13-5 | Brush clearance shall be conducted prior to initiation of construction activities in accordance with Fire Department requirements. | |
| | 4.13-6 | Additional access requirements may be needed during the building construction process. | |
| | 4.13-7 | Adequate water availability shall be provided to service construction activities. | |

## Table ES-1 (continued)
## Summary of Project Impacts and Recommended Mitigation Measures

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.13 FIRE SERVICES (continued)** | | |
| | 4.13-8 Installation of 79 public and 24 private on-street fire hydrants is required. The required fire flow for 20 public fire hydrants located on Newhall Ranch Road, adjacent to Area C and Area D, is 5,000 gpm at 20 psi for five hours with three fire hydrants flowing. 59 public fire hydrants are required to be installed on all other streets, including Newhall Ranch Road, as indicated on the Tract Map. The required fire flow is 1,250 gpm at 20 psi for two hours with one fire hydrant flowing. 24 on-site fire hydrants are required within Area C and Area D. The required fire flow is 2,500 gpm at 20 psi for two hours with two fire hydrants flowing simultaneously. | |
| | 4.13-9 Vehicular access must be provided and maintained serviceable throughout construction to all required fire hydrants. All required fire hydrants shall be installed, tested and accepted or bonded prior to construction. All hydrants shall measure 6 inches by 4 inches x 2 1/2 inches brass or bronze, conforming to current AWWA standard C503 or approved equal. All on-site hydrants shall be installed a minimum of 25 feet from a structure or protected by a two-hour rated firewall. These hydrants shall be located as per the Vesting Tentative Tract Map on file with the Fire Department. | |
| | 4.13-10 Fire Department access shall be extended to within 150 feet distance of any exterior portion of all structures. | |
| | 4.13-11 Access shall comply with Section 902 of the Fire Code, which requires all weather access. All weather access may require paving. | |
| | 4.13-12 All private gates shall comply with Regulation 5 of the Fire Code. Prior to approval of the Tentative Tract Map, the applicant shall receive approval of the gates from the Los Angeles County Fire Department. | |
| | 4.13-13 All fire lanes must not be less than 26 feet paved width (clear to sky and unobstructed) and posted and red curbed "NO PARKING - FIRE LANE". | |
| | 4.13-14 The trail system shall provide adequate access for emergency vehicles. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.13 FIRE SERVICES (continued)** | | |
| | 4.13-15 Where driveways extend further than 300 feet and are of single access design, turnarounds suitable for fire protection equipment use shall be provided and shown on the final map. Turnarounds shall be designed, constructed, and maintained to insure their integrity for Fire Department use. Where topography dictates, turnarounds shall be provided for driveways that extend over 150 feet in length. | |
| | 4.13-16 Private driveways shall be indicated on the final map as "Private Driveway and Fire Lane" with the widths clearly depicted and shall be maintained in accordance with the Fire Code. | |
| | 4.13-17 Provide Fire Department or City approved street signs and building access numbers prior to occupancy. | |
| | 4.13-18 Additional access requirements include:<br>• A second means of access is required prior to the construction of the 501st dwelling unit. The number of dwelling units includes all single-family homes, and all units within the apartments and townhomes.<br>• Temporary turnarounds are required for the end of Newhall Ranch Road and the end of Santa Clarita Parkway. The turnarounds shall be either a cul-de-sac bulb with a 32-foot centerline or a hammer-head design, which would be posted and red curbed "NO PARKING - FIRE LANE". These temporary turn-arounds are required to stay in place until the bridges have been completed and are opened to an existing street.<br>• All streets with center medians shall have a minimum paved width of 20 feet on each side of the median, with street posted and red curbed "NO PARKING - FIRE LANE". | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.13 FIRE SERVICES (continued)** | | |
| | • Street widths for this project shall conform to the widths indicated on the cross-section on this Vesting Tentative Tract Map. All street widths shall be measured from the curb flow line to curb flow line.<br>• The traffic circle at the end of "N" Street is approved. The area surrounding the traffic circle shall be posted and red curbed "NO PARKING - FIRE LANE".<br>• Due to "N" Street extending greater than 700 feet in length, "N" Street shall have a minimum street width of 36 feet, curb-flow-line to curb-flow-line, not 34 feet as indicated on the map. Provide four revised copies of this page only of the Tract Map indicating this correction. This is required to be submitted to the Land Development Unity prior to any approvals of this Tract Map.<br>• For on-site access in Area C and Area D, provide a minimum unobstructed driveway width of 28 feet, clear-to-sky posted and red curbed "NO PARKING - FIRE LANE". Each turning radius shall be 42 feet from the centerline. | |
| **4.14 SHERIFF SERVICES** | | |
| Project implementation would impact the current level of Sheriff's Department protection services through a project-generated increase in service calls. Implementation of mitigation measures would reduce project impacts of Sheriff's protection services to less than significant levels. | **a. Mitigation Measures Already Incorporated into the Project** | |
| | 4.14-1 During construction, private security patrols shall be utilized to protect the project site. | Not Significant |
| | **b. Mitigation Measures Proposed by This EIR** | |
| | 4.14-2 As final building plans are submitted to the City for approval in the future, Sheriff's Department design requirements which reduce demands for service and ensure adequate public safety (such as those pertaining to site access, site security lighting, shall be incorporated into building designs. | |
| | 4.14-3 Project design shall landscape the project site with low-growing groundcover and shade trees, rather than a predominance of shrubs which could conceal potential criminal activity around buildings and parking areas. | |
| | 4.14-4 Project design shall provide lighting, to the satisfaction of the Sheriff's Department, around and throughout the development to enhance crime prevention and enforcement efforts. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.14 SHERIFF SERVICES (continued)** | | |
| | 4.14-5 Project design shall provide clearly visible (during the day and night) address signs and/or building numbers for easy identification during emergencies. | |
| | 4.14-6 Project design shall provide visibility of doors and windows from the street and between buildings. | |
| | 4.14-7 Project site design shall include adequate parking spaces in the parking lots to accommodate shoppers, employees and residents. | |
| **4.15 HUMAN MADE HAZARDS** | | |
| The proposed Riverpark project is not expected to include any uniquely hazardous land uses. Both residential and commercial proposed uses are expected to use and store chemicals and/or substances that are typically found in similar settings. There are several abandoned oil wells within the project site that were used for crude oil production. Based on the extremely limited productivity of these wells, they were ultimately abandoned. As crude oil is not considered to be a hazardous material, residential and non-residential development in areas previously occupied by the oil production facilities would not result in environmental safety hazards to future residents, employees, and/or visitors. Electrical transmission lines are located to the east of the project site. | There are no human made hazards located on the project site; therefore no mitigation measures are required. | Not Significant |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.16 VISUAL RESOURCES** | | |
| Views of the existing open space areas from each of the view corridors would be altered due to development of proposed residential and commercial uses. The images of the project's residential and commercial development, bank stabilization, roadways, and other human activity along the Santa Clara River would, overall, be a significant change from the existing characteristics of the project site. | 4.16-1 Taller growing trees and/or shrubs shall be planted along Newhall Ranch Road, the river trail and Santa Clarita Parkway borders of the project site in order to screen the project and minimize the potential for light and glare impacts. Shade trees shall be planted at the commercial site to provide visual relief and help to reduce ambient temperatures. | Significant |
| | 4.16-2 All parking lot pole lights and streetlights shall be fully hooded and back shielded to reduce the light "spillage" and glare. | |
| | 4.16-3 The project applicant shall consult with the City Department of Transportation and Engineering Services and Southern California Edison to develop a street lighting program that will allow for reduced streetlight to reduce lighting spillover into the Santa Clara River. | |
| | 4.16-4 All trail and community park lighting shall provide optimum safety while at the same time reducing light "spillage" and glare. | |
| The project would result in grading of ridgelines classified by the City as secondary ridgelines (see discussion in **Section 4.7, Land Use**), bank stabilization and conversion of the site from vacant land to a man-made urban environment. The proposed project would be most visible from Bouquet Canyon Road, Soledad Canyon Road, the extension of Newhall Ranch Road, the proposed and future extension of Santa Clarita Parkway and the existing residential, commercial, and business parkland uses to the west, south and southeast of the project site. Incorporation of recommended mitigation measures would reduce project-level and cumulative visual impacts caused by converting the project site from an undeveloped to a developed urban area, but not to a level less than significant. | 4.16-5 The colors of exposed bank stabilization structures shall be earth tones, which blend with the surrounding natural environment. Wall surfaces shall be variously textured to diffuse lighting and minimize reflectivity. | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.17 POPULATION/HOUSING/EMPLOYMENT** | | |
| The 1,183 residential units proposed for the project would house approximately 3,615 persons. Relative to the year 2010 City and Santa Clarita Valley population projections, population generated by the project is considered negligible (2.0 and 1.3 percent of the 2010 projections, respectively). The project would also create 94 jobs at the commercial retail use.<br><br>Although the existing City's General Plan designations for the site are proposed to be changed, the proposed General Plan Amendment would reduce on-site density or intensity of residential use compared to that allowed under the existing General Plan, and it would generate less population than allowed on the site. Project population, housing, and employment would also be within growth projections for the City and the Santa Clarita Valley. Therefore, the proposed project would not exceed City or regional population, housing, and employment projections and would not result in a significant impact relative to population and housing. | No mitigation is required. | Not Significant |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | | Recommended Mitigation Measures | Residual Impact |
|---|---|---|---|
| **4.18 CULTURAL RESOURCES** | | | |
| Phase I and II archaeological surveys of cultural resources in the proposed project area were undertaken. These surveys have resulted in the discovery and recording of three prehistoric and one historic archaeological sites. Phase II archaeological studies were conducted at two of the prehistoric archaeological sites.<br><br>The second site contains a subsurface archeological deposit and intact prehistoric artifacts that can contribute to the scientific reconstruction of prehistoric lifeways in the Santa Clara River Valley. This site is culturally significant and the applicant has designed the project so as to preserve it in situ in perpetuity within the open space areas.<br><br>Inadvertent direct and/or indirect disturbance during construction of the proposed project to any sensitive cultural resource found on the site would be considered a significant impact. Mitigation measures are proposed that reduce the magnitude of potential impacts to cultural resources to less than significant levels. | **a.** | **Mitigation Measures Incorporated into the Project** | |
| | 4.18-1 | CA-LAN-351 contains a subsurface archaeological deposit and intact prehistoric artifacts that can contribute to the scientific reconstruction of prehistoric lifeways in the Santa Clara River Valley. This site shall be preserved in its current state in perpetuity as is demonstrated on VTTM 53425. | Not Significant |
| | **b.** | **Mitigation Proposed by the EIR** | |
| | 4.18-2 | Archaeological site CA-LAN-3043 contains an intact subsurface deposit and artifacts that hold the potential for contributing to our understanding of the prehistory of this portion of California. A Phase III data recovery (salvage excavation) program shall be conducted for CA-LAN-3043 prior to grading activities. | |
| | 4.18-3 | Although no other significant cultural resources were observed or recorded during the surface field survey, all grading activities and surface modifications must be confined to only those areas of absolute necessity to reduce any form of impact on unrecorded (buried) cultural resources that may exist within the confines of the project area. In the event that resources are found during construction, activity shall stop and a qualified archaeologist shall be contacted to evaluate the resources. If the find is determined to be a historical or unique archaeological resource, contingency funding and a time allotment sufficient to allow for implementation of avoidance measures or appropriate mitigation should be available. Construction on other parts of the project will be subject to Public Resources Code §21083.2(i). | |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.19 AGRICULTURAL RESOURCES** | | |
| The proposed project would convert 73 acres of prime agricultural land to urban uses. The conversion of prime agricultural land is irreversible, and is considered an unavoidable significant impact. However, in light of the continuing trend by the County to convert cultivated lands to urban uses to accommodate growth, and the fact that the site is surrounded by development, the project site is impaired (i.e., relatively difficult and less economical to farm). Although the site is generally of lower value than larger and better-situated parcels found to the west and the loss of agricultural productivity on prime agricultural land under such circumstances is t considered a significant and unavoidable project and cumulative impact. | There is no feasible mitigation for the loss of agricultural land. | Significant |
| The conversion of prime agricultural land is irreversible and is, therefore, considered an unavoidable significant impact. | | |
| **4.20 FLOODPLAIN MODIFICATION** | | |
| The proposed project would modify the floodplain by placing bank stabilization and erosion protection along selected portions of the river, developing the floodplain areas behind the bank stabilization, and installing a bridge across the river. These actions would alter flows in the river; however, the effects would only be observed during infrequent flood events that reach the buried banks (e.g., 50-year and 100-year flood events). The proposed project would cause an increase in flows and changes in water velocities and water depth; and changes in the flooded areas. However, these hydraulic effects would be localized and minor in magnitude and extent, would be limited to the project footprint, and would be insufficient to alter the amount, location, and nature of aquatic and riparian habitats in the project area and downstream. Under the project, the river would still retain sufficient width to allow natural fluvial processes to continue. Hence, the mosaic of habitats in the river that support various sensitive species would be maintained, and the populations of the species within and adjacent to the river corridor would not be significantly affected. | No mitigation measures are required. | Not Significant |

**Table ES-1 (continued)**
**Summary of Project Impacts and Recommended Mitigation Measures**

| Project Impacts | Recommended Mitigation Measures | Residual Impact |
|---|---|---|
| **4.21 WASTEWATER DISPOSAL** | | |
| The proposed project, located entirely within the service boundaries of the Saugus Water Reclamation Plant (District 26), would generate approximately 0.26 million gallons of wastewater on a daily basis. This effluent would be treated at both the Saugus Water Reclamation Plant (District 26) as well as the Valencia Water Reclamation Plant (County Sanitation District 32), which together, form the Santa Clarita Valley Joint Sewerage System. These two facilities have a combined permitted treatment capacity of 19.1 mgd with an average treatment volume of 17.3 mgd. Based on the impact analysis prepared for the proposed project, neither project nor cumulative wastewater impacts would be significant. | The proposed project would not result in any significant impacts. However, as is standard operating procedure for development projects in the City of Santa Clarita, the following measures are required to be incorporated into a project's approval process and design. | |
| | 4.10-1 Applicant shall obtain will-serve letter from County Sanitation Districts of Los Angeles County prior to issuance of building permits in order to verify that there is sufficient capacity in the receiving trunk lines and the reclamation plant to serve the project. | Not Significant |
| | 4.10-2 All local wastewater lines within the project boundaries are to be constructed by the applicant and dedicated to the City of Santa Clarita Transportation and Engineering Services Department. | |
| | 4.10-3 Prior to issuance of building permits, the applicant shall pay wastewater connection fees. | |

Pages omitted.

Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

# 4.8 WATER SERVICE

## 1. EXISTING CONDTIONS

### a. Preface

This section describes the existing water purveyors in the Santa Clarita Valley and their service areas, and summarizes important characteristics applicable to the water service area in the Santa Clarita Valley, which includes the project site. The data found in the section provides an important backdrop to understanding water supplies and demand in the Santa Clarita Valley generally, as well as understanding the Riverpark project's water demand and supplies. Please see **Figure 4.8-1** for an illustration of the existing water reclamation plants and sanitation districts.

### b. Existing Water Service Area Characteristics

To understand water supplies and demand in the Santa Clarita Valley, it is important to highlight some of the important local conditions or characteristics of the area. These local conditions affect water demand and supplies in the Santa Clarita Valley and surrounding areas. The section describes local climatic conditions, regional demographics, existing topography and regional area geology and surface water flows in the Santa Clarita Valley and downstream.

In addition, the section briefly summarizes the effects of statewide drought conditions on the Santa Clarita Valley. As explained below, in general, there was minimal impact on the Santa Clarita Valley prior to the 1990-1991 statewide drought conditions. The 1990-1991 statewide drought impacted water supplies in the Santa Clarita Valley; however, on balance, the Santa Clarita Valley responded well to those drought conditions. Since the 1990-1991 drought, the Castaic Lake Water Agency (CLWA) and the other retail water purveyors have continued to work cooperatively to ensure that water demands are met in response to varying hydrologic conditions and increasing demand from existing and planned growth. This effort includes the decision by the Santa Clarita Valley's water agencies[1] to jointly prepare the Urban Water Management Plan (UWMP). The UWMP describes current and future implementation of water conservation measures (called Water Demand Management Measures) within the CLWA service area (shown on **Figure 4.8-8** below), and it updates the Santa Clarita Valley's Water Shortage Contingency Plan.

1 Los Angeles County Waterworks District 36 is not required to prepare a UWMP because it has less than 3,000 connections and, consequently, did not participate in this effort.





#### (1) Climate

The climate in the Santa Clarita Valley is generally characterized as semi-arid and warm. Summer months are dry with temperatures that can reach as high as 110° F. Winter months are somewhat cool with temperatures that can drop as low as 20° F. Typically, "dry" years (less than 10 inches of rainfall per year) are followed by "wet" years (greater than 20 inches of rainfall per year) in a cyclical pattern. Average rainfall is approximately 19 inches per year in the flat areas and approximately 27 inches per year in the mountains. The region, including the Santa Clarita Valley, is subject to wide variations in annual precipitation.[2] **Figure 4.8-2** illustrates the annual rainfall in the Santa Clarita Valley and graphically depicts the time periods with low rainfall.

#### (2) Regional Demographics

The purveyors provide water service to residential, commercial, and industrial customers within CLWA's service area, including Santa Clarita Valley. Water service is also provided for other uses, such as fire service and utility line cleaning.

CLWA reports that the number of new service connections in its service area increased from 39,299 in 1990 to 58,221 in 2003 (See, **Table 4.8-1**). As shown on **Table 4.8-1**, the increase in the number of new service connections was slightly more than 500 connections per year in 1991, to a maximum of 4,200 connections in 2001, representing an average annual increase of 1,456 new service connections.

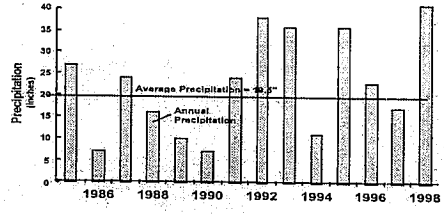
**Table 4.8-1**
**Historical Number of Service Connections**

| Service Connections | 1990 | 1992 | 1994 | 1996 | 1998 | 2000 | 2002 |
|---|---|---|---|---|---|---|---|
| Valencia Water Co. | 14,272 | 14,854 | 15,703 | 17,420 | 19,863 | 22,000 | 25,286 |
| Newhall County | 5,854 | 6,144 | 6,294 | 6,477 | 6,585 | 7,200 | 7,700 |
| Santa Clarita Water Division of CLWA | 18,550 | 19,000 | 19,400 | 19,650 | 20,300 | 22,000 | 24,175 |
| LA County #36 | 623 | 736 | 752 | 768 | 774 | 700 | 1,060 |
| Total | 39,299 | 40,734 | 42,149 | 44,315 | 47,522 | 51,900 | 58,221 |

*Source: CLWA 2000; Santa Clarita Valley Water Report 2000 and 2002.*

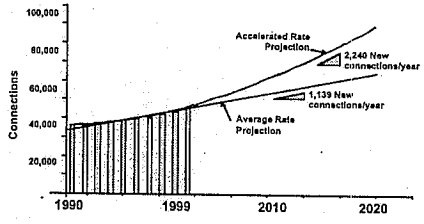
2 See, Newhall Ranch ASR Impact Evaluation, prepared by CH2MHill, February 2001, Section 4.

Figure 4.8-2
Rainfall in the Santa Clarita Valley

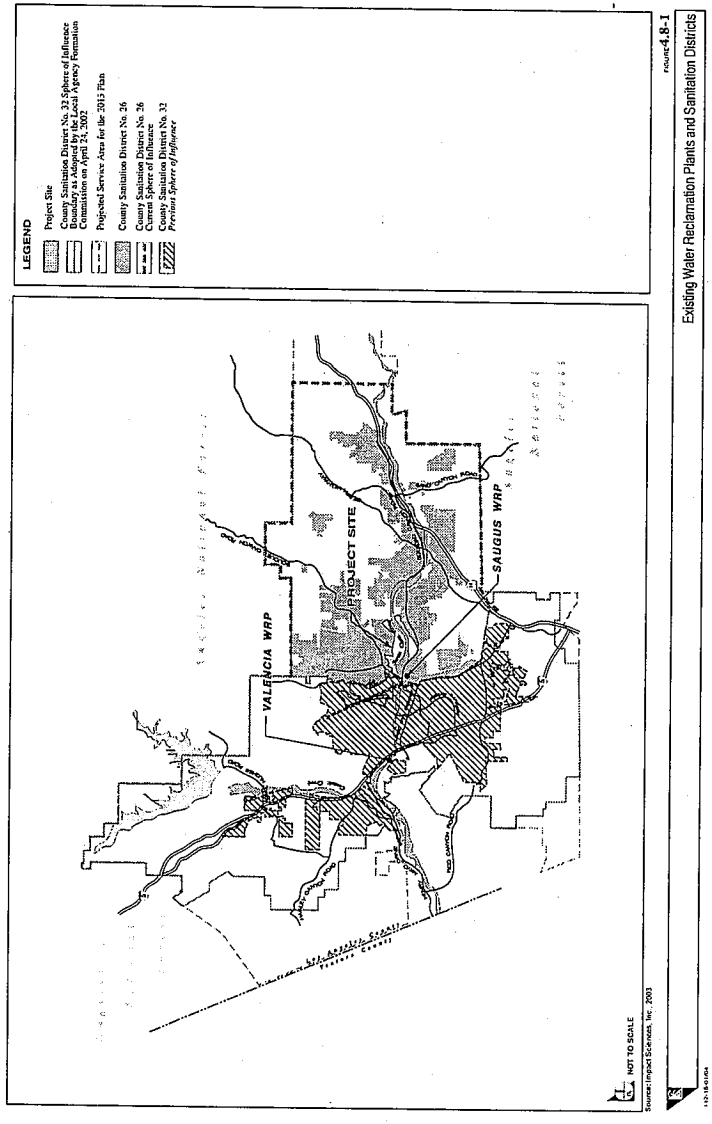



To determine the future number of service connections in the CLWA service area, CLWA used two different projection techniques. Using an "average rate" regression technique, the number of connections is projected to be about 70,000 in the year 2020. Under the second technique (accelerated rate projection), CLWA projects the connections to be about 96,000 by the year 2020. **Figure 4.8-3** depicts the historical and projected number of service connections in the CLWA service area.

Figure 4.8-3
Historical and Projected Number of Service Connections






Existing Water Reclamation Plants and Sanitation Districts

### (3) Topography

The CLWA service area encompasses the relatively flat-lying Santa Clarita Valley, the eastern portion of the Santa Clara River Valley and portions of the surrounding hills and mountains. The mountains include the Santa Susana and San Gabriel Mountains to the south and the Sierra Pelona and Leibre-Sawmill Mountains to the north. Elevations range from about 800 feet on the valley floor to about 6,500 feet in the San Gabriel Mountains. The headwaters of the Santa Clara River are at an elevation of about 3,200 feet at the divide separating this hydrologic area (i.e., the Upper Santa Clara River Hydrologic Area) from the Mojave Desert.

The Riverpark project is located within the Santa Clara River Valley Groundwater Basin, East Subbasin (Basin No. 4-4.07).[3] This area is upstream of the other groundwater basins in the Santa Clara River Valley drainage. The western end of the East Subbasin extends to roughly the Los Angeles County/Ventura County boundary line. The Piru groundwater basin is located to the west in Ventura County. The two groundwater basins are connected through relatively thin alluvial deposits (in the Alluvial Aquifer) that overlie relatively impermeable Pico Formation bedrock deposits at this location. Groundwater in the Santa Clarita Valley also discharges to the Santa Clara River, which flows into Ventura County.

### (4) Regional Geology

The geology within and adjacent to the CLWA service area consists of relatively thin alluvial deposits (Alluvium) overlying a deeper, relatively thick Saugus Formation in certain areas. Figure 4.8-4 delineates the location of the Alluvium and the Saugus Formation. As discussed in further detail below, both the Alluvium and Saugus Formation contain water-bearing sediments capable of becoming saturated so as to provide water to wells. These water-bearing sediments constitute the local "groundwater reservoir" for the Santa Clarita Valley.[4]

The upper basin, called the Alluvium or Alluvial Aquifer, generally underlies the Santa Clarita Valley and side canyons. The main river valley consists of medium-grained sand on the west to cobbly sand in the east. Due to the unconsolidated to poorly-consolidated condition of the Alluvium, and its lack of cementation, the Alluvium has relatively high permeability and porosity. The maximum thickness of the Alluvium varies along the Santa Clarita Valley, but is generally considered to be 200 feet.

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3 California Department of Water Resources Bulletin 118.

4 This section is based on information from the Newhall Ranch ASR Impact Evaluation, prepared by CH2MHill, February 2001, Sections 3 and 4, and Hydrogeologic Conditions in the Saugus Formation, Santa Clarita Valley, California, prepared by Richard C. Slade & Associates, LLC, January 2001. This report is located in **Appendix 4.8.**



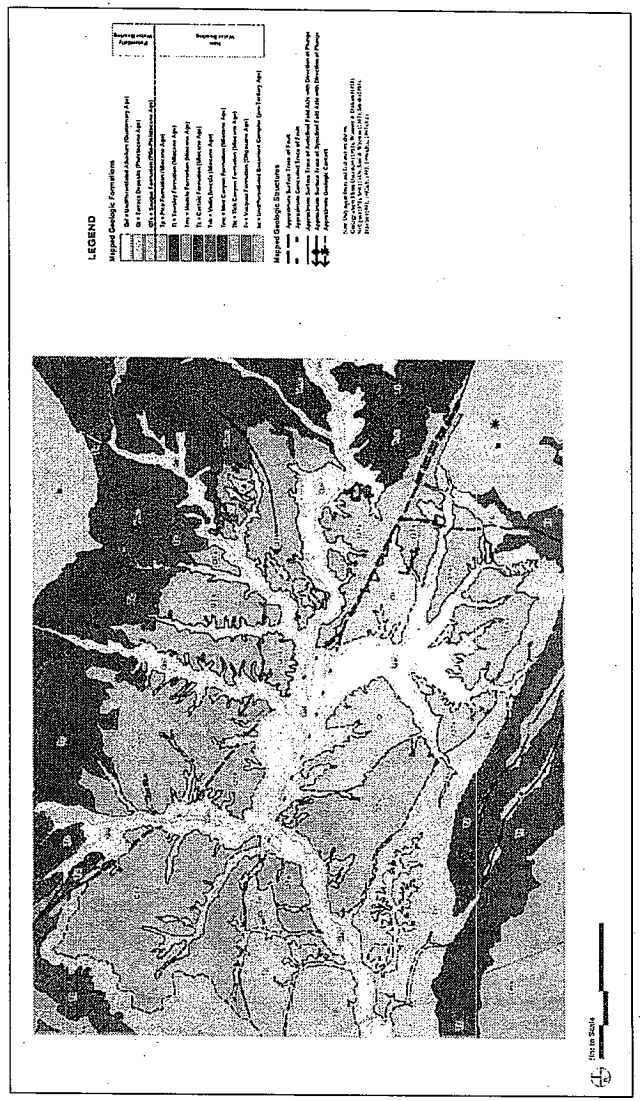


Figure 4.8-4
Location of the Alluvial and Saugus Formation

The groundwater is pumped from wells up to 200 feet in depth. The Alluvium is estimated to store over 240,000 acre-feet of water. It has supplied approximately 30,000 to 40,000 acre feet per year (AFY) in average/normal years, and 30,000 to 35,000 AFY in dry years. The annual average groundwater production from the Alluvial Aquifer during the 1990s was approximately 33,500 AFY.

Underlying the Alluvium deposits in the main portion of the Santa Clarita Valley is the Saugus Formation. The Saugus Formation consists of unconsolidated to semi-consolidated sandstone and conglomerate materials. Two faults, the active San Gabriel Fault, and the potentially-active Holser Fault, traverse the Santa Clarita Valley. Although maximum thickness of the Saugus Formation is reported to be 8,500 feet, the estimated water-bearing thickness of the formation ranges from 5,500 feet between the San Gabriel Fault and the Holser Fault to 1,500 feet northeast of the San Gabriel Fault. It is estimated that the amount of groundwater in storage in the Saugus Formation is about 1.65 million acre feet. Of the 1.65 million acre feet, the area north of the San Gabriel Fault is estimated to contain approximately 130,500 acre feet, the area between the Holser and San Gabriel Faults is estimated to contain approximately 641,000 acre feet and the area south of the Holser Fault is estimated to contain approximately 641,000 acre feet. The Saugus Formation is pumped by wells extending to about 2,000 feet in depth. It has supplied approximately 7,500 to 15,000 AFY in average/normal years, and 11,000 to 15,000 AFY in dry years.

**(5) Hydrology of the Santa Clarita Valley**

Most of the CLWA service area is within the Santa Clarita Valley Groundwater Basin, East Subbasin. The primary drainage course in the service area is the Santa Clara River.[5] **Figure 4.8-5** depicts the geology and hydrologic cycle in Santa Clarita Valley. **Figure 4.8-6** shows the Santa Clara River, East Subbasin, with respect to other groundwater basins downstream of the Specific Plan area. **Figure 4.8-7** shows the locations of production wells in the Alluvial Aquifer and Saugus Formation.

The Santa Clara River and its tributaries flow generally westward from the Santa Clarita Valley to the Pacific Ocean. The principal tributaries to the Santa Clara River include Mint Canyon, Bouquet Canyon, San Francisquito Canyon and Castaic Creek. Water flow in the canyon areas is ephemeral, and diminishes rapidly after most rainfall events. The local surface water bodies include the Santa Clara River, Bouquet Reservoir and Castaic Lake. Various reaches of the Santa Clara River were listed by EPA in 1999 as impaired due to high concentrations of chloride, nitrogen, nitrates and nitrites, high coliform count and dissolved oxygen.

5 The information contained in this section is from Newhall Ranch ASR Impact Evaluation, prepared by $CH_2MHill$, February 2001, and an updated technical memorandum prepared by $CH_2MHill$.





The sources of surface water in the Santa Clarita Valley include precipitation, irrigation return flows, groundwater discharge, stormwater releases from Castaic Lake and Bouquet Reservoir, and treatment plant discharges to the Santa Clara River from the two existing water reclamation plants (WRPs). Another significant source of surface flow comes from the increased importing of State Water Project (SWP) water supplies by CLWA to its service area.

Since 1980, CLWA has been importing SWP water as a supplemental water source to the retail water purveyors in its service area. The total amount of SWP water delivered to the service area from 1980 through 2002 was 405,062 acre feet.

In order to evaluate historical and projected surface flow to downstream from imported SWP water in Santa Clarita Valley, an updated technical memorandum was prepared by $CH_2MHill$ (February 2001). The objective of the updated technical memorandum was to estimate the historical and projected flow to downstream due to the importation of SWP water by CLWA and the use of that water in the Santa Clarita Valley.

Based on the updated technical memorandum, imported SWP water is used to meet both residential and non-residential interior and exterior water demands. A portion of the imported SWP water finds its way into the Santa Clara River watersheds where it recharges local aquifers and flows downstream to Ventura County. Stream gage data collected at the County line (USGS Gage No. 11108500) from 1953 to 1996 demonstrates a 60 percent increase in average annual flow since the importation of SWP water, even during dry years (the annual flow of 17,596 cubic feet per second (cfs) in 1991, a drought year, exceeds the annual average flow prior to importation of 16,479 cfs). The source of this additional flow in the Santa Clara River watershed includes imported SWP water.

The SWP water used to meet residential and non-residential interior water demands ultimately reaches the local existing WRPs in the Santa Clarita Valley. Historically, the treated water has been discharged to the Santa Clara River, where it contributes significantly to the natural surface water and groundwater flows reaching Ventura County. As discussed below, although a significant portion of the imported water used for irrigation is lost through evapotranspiration to the atmosphere, SWP water has significantly increased the flow of surface water and groundwater flows in the Santa Clara River watershed.

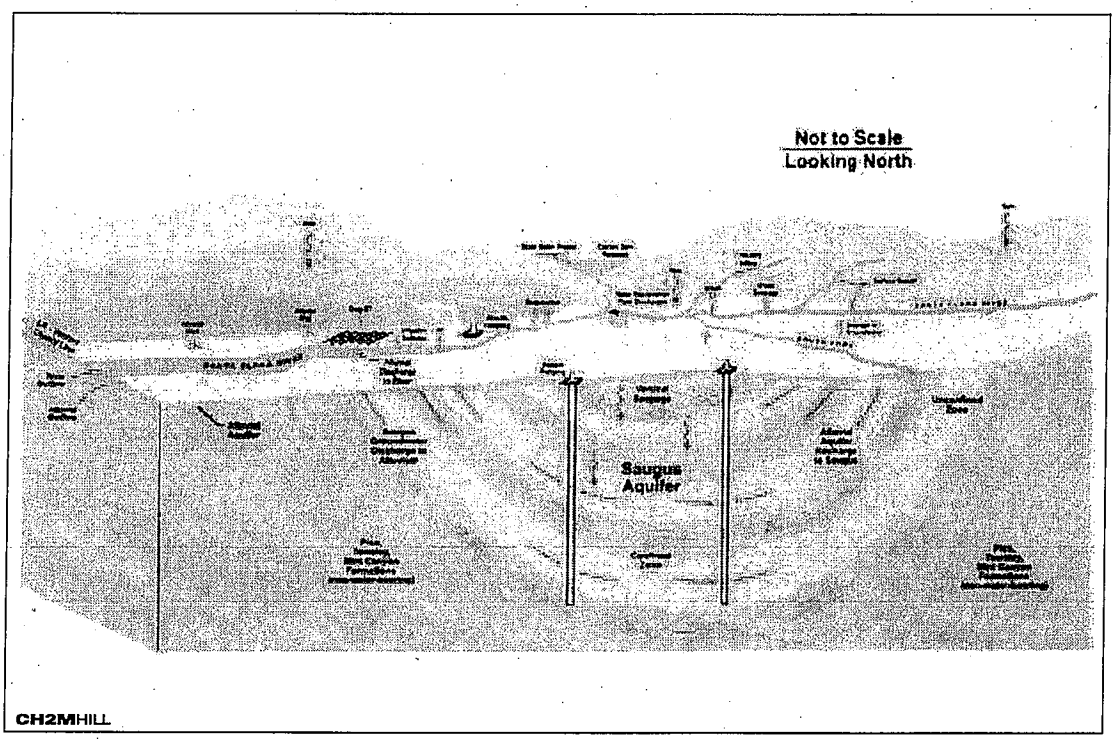


FIGURE 4.8-5

Geology And Hydrologic Cycle–Santa Clarita Valley

112-16-11/03

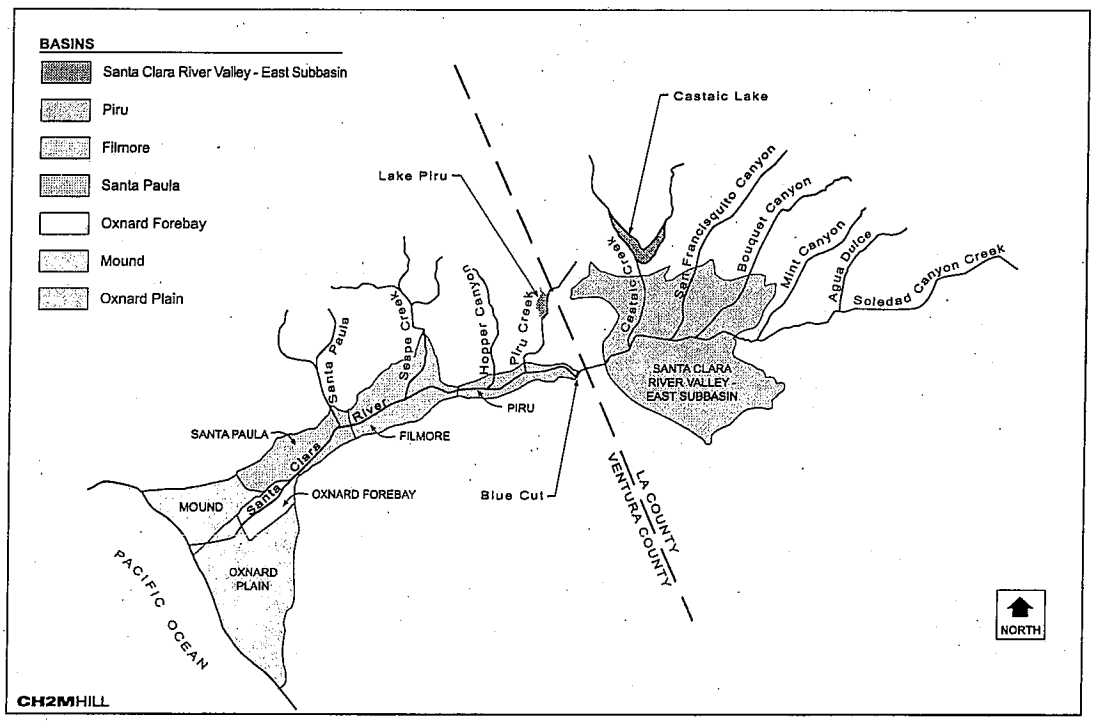


FIGURE 4.8-6

Groundwater Basins in the Santa Clara River Drainage

112-16-11/03

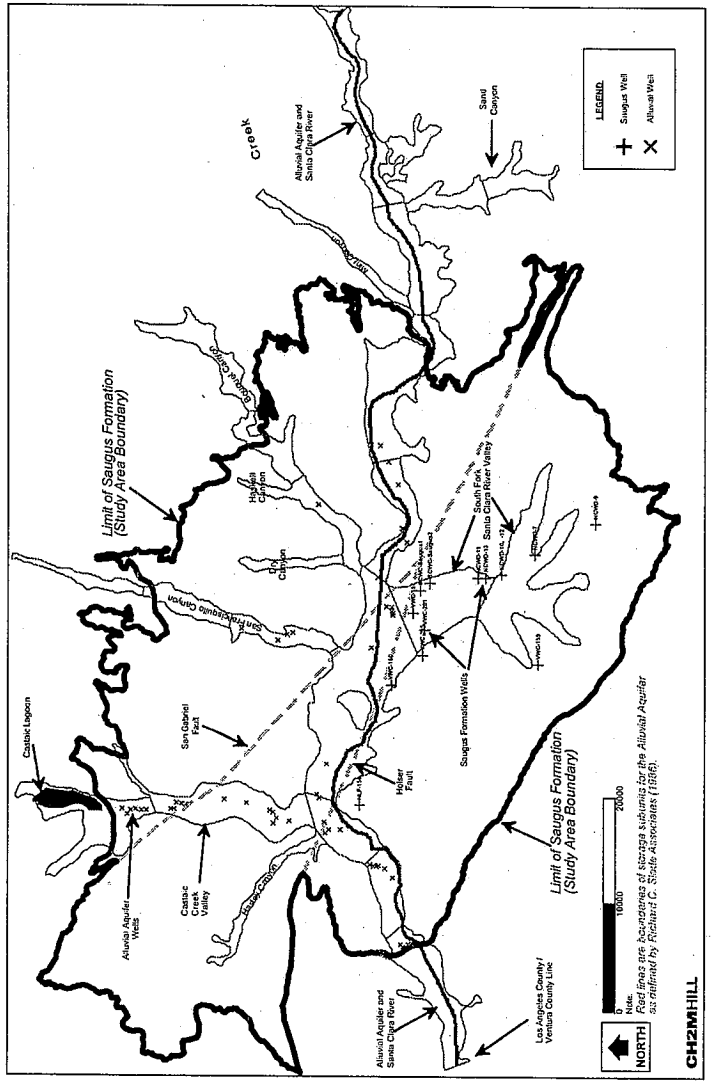


FIGURE 4.8-7

Groundwater Production Well Locations–Santa Clarita Valley

112-16-11/03

Again, the total amount of SWP water delivered to the service area from 1980 through 2002 was 405,062 acre feet. Based on the updated technical memorandum, it is estimated that approximately 136,544 acre feet of imported SWP water has been added to the Santa Clara River through return flow and discharges from existing water treatment plants in Santa Clarita Valley. It is estimated that approximately 18,000 AFY enhanced the watershed and flowed downstream to Ventura County in 1999.

In the future, when CLWA takes its full 95,200 AFY allocation of SWP water, $CH_2MHill$ estimates that approximately 22,160 AFY will enhance the watershed and flow to Ventura County ($CH_2MHill$, 2001). Consequently, similar to other watersheds where water importation has occurred (e.g., Santa Ana River), the flow in the Santa Clara River watershed is, and will continue to be, significantly enhanced by importing SWP water to the watershed. The importing of SWP water, and the use of that water in the CLWA service area, will continue to result in a net benefit in the amount of surface flow into Ventura County.

**(6) Effects Of Drought**

Drought cycles will affect the project in two ways. First, local droughts in the Santa Clarita Valley historically have resulted in short-term increased water demand, short-term increased groundwater pumping, and short-term decreased recharge to the local groundwater system. Second, a statewide drought affects water availability in the SWP system and ultimately deliveries from the SWP system. Droughts have occurred locally in 1947-1950, 1958-1960 and 1990-1991. Recent statewide droughts have occurred in 1976-1977 and 1987-1992.[6] Since the area's water supplies are dependent upon rainfall conditions both locally and statewide, it is important to note that wet and dry year conditions do not occur at the same time in Northern and Southern California. As a result, the water purveyors in Santa Clarita Valley are able to adjust the mix of available water resources on a year-to-year basis in response to local and statewide hydrologic conditions.

Prior to 1990-1991, drought conditions statewide had a minimal impact upon the Santa Clarita Valley other than requiring additional water supply to compensate for the lack of spring rainfall for irrigation (e.g., crops, lawns and gardens). In 1990-1991, however, for the first time, statewide drought conditions caused cutbacks in imported SWP supplies in the Santa Clarita Valley. Water production also declined in

6 The 1987-1992 drought was notable for its six-year duration. Statewide reservoir storage was about 40 percent of average by the third year of the drought. The State Water Project met contractors' delivery requests during the first four years of the drought, but then was forced by declining reservoir storage to reduce deliveries substantially. The SWP terminated deliveries to agricultural contractors and provided about 30 percent of requested urban deliveries in 1991, the single-driest year of the drought. A 1991 Governor's executive order resulted in implementation of a State drought water bank. (Critical Water Shortage Contingency Plan, Governor's Advisory Drought Planning Panel, December 29, 2000.)

some wells operating in the shallow, outlying reaches of the Alluvial Aquifer. However, because Santa Clarita Water Division's alluvial wells are located in the major water bearing reaches of the aquifer, none of SCWD's alluvial wells experienced loss of production during 1990-1991 (CLWA acquired the Santa Clarita Water Company, an investor-owned retail water company serving the eastern part of the Santa Clarita Valley. The former Santa Clarita Water Company was incorporated into CLWA's Santa Clarita Water Division, which continues to serve the same area with Santa Clarita Water Company's facilities. Additional details regarding the Santa Clarita Water Division of CLWA is provided below). In addition to the alluvial groundwater supplies, the water purveyors in Santa Clarita Valley pumped more water from the Saugus Formation in 1990-1991, and requested that their customers voluntarily conserve water by 10 percent. Actual water use in the valley decreased more than 10 percent as a direct result of water conservation efforts.

Due to the steps taken by the local purveyors, water demands in the Santa Clarita Valley were met for the duration of the 1990-1991 drought. CLWA also elected not to participate in the state's Drought Water Bank because alternate local supplies were available to meet water demands in the Santa Clarita Valley. In addition, members of the Santa Clarita Valley Water Purveyors signed a Drought Emergency Water Sharing Agreement, agreeing to share water from all sources, and to facilitate beneficial water transfers, exchanges and wheeling arrangements. The purveyors also worked with the City of Santa Clarita and the County of Los Angeles to implement water use ordinances for Santa Clarita Valley residences, review water consumption and supply data and recommend measures to encourage conservation.

Since the 1990-1991 drought, CLWA and the other retail water purveyors have continued to work cooperatively to ensure customer demands are met under varying hydrologic conditions and with overall increasing demands from planned growth. These efforts have included water resource planning activities, acquisition of new water supplies and construction of transmission and treatment facilities, as discussed in further detail below. These efforts include the decision by most of the Santa Clarita Valley's water agencies to jointly prepare the UWMP. The UWMP describes current and future implementation of water conservation measures (called Water Demand Management Measures) within the CLWA service area. These conservation measures are described in Chapter 5.0 of the UWMP. The UWMP also includes an update to the Santa Clarita Valley's Critical Water Shortage Contingency Plan. The updated plan is based on the water agencies' actual experience in addressing water shortages in the Santa Clarita Valley in 1991 (due to the continuation of the 1990-1991 statewide drought) and in 1994 (due to the 1994 Northridge earthquake). The updated plan is described in Chapter 6.0 of the UWMP.

At the state level, significant changes have also occurred in California's water management framework since the last statewide drought of 1987-1992. For further information regarding these statewide changes,





please refer to the heading, **Imported SWP Water Supplies; SWP Reliability** and Critical Water Shortage Contingency Plan, Governor's Advisory Drought Planning Panel, December 29, 2000 (Chapter 2).

**(7) Effects Of Urbanization on Aquifer Recharge in the Santa Clarita Valley**

In a groundwater basin, the effect of urbanization on recharge to underlying groundwater is dependent on land uses, water uses, vegetative cover, and geologic conditions. Groundwater recharge from undeveloped lands occurs from precipitation alone, whereas areas that are developed for agricultural or urban land uses receive both precipitation and irrigation of vegetative cover. In an urban area, groundwater recharge occurs directly beneath irrigated lands and in drainages whose bottoms are not paved or cemented. A memorandum prepared by $CH_2MHill$ entitled Effect of Urbanization on Aquifer Recharge in the Santa Clarita Valley (February 22, 2004; see **Appendix 4.8**) discusses the general effects of urbanization on groundwater recharge and the specific effects in the Santa Clarita Valley. The findings of that memorandum is presented below.

In the Santa Clarita Valley, stormwater runoff finds its way to the Santa Clara River and its tributaries, whose channels are predominantly natural and consist of vegetation and coarse-grained sediments (rather than concrete). The stormwater that flows across paved lands in the Santa Clarita Valley is routed to stormwater detention basins and to the river channels, where the porous nature of the sands and gravels forming the streambeds allow for significant infiltration to occur to the underlying groundwater.

Increased urbanization in the Valley has resulted in the irrigation of previously undeveloped lands. The effect of irrigation is to maintain higher soil moisture levels during the summer than would exist if no irrigation were occurring. Consequently, a greater percentage of the fall/winter precipitation recharges groundwater beneath irrigated land parcels than beneath undeveloped land parcels. In addition, urbanization in the Santa Clarita Valley has occurred in part because of the importation of State Water Project (SWP) water, which began in 1980. SWP water use has increased steadily, reaching nearly 44,500 acre-feet (AF) in 2003. Two-thirds of this water is used outdoors, and a portion of this water eventually infiltrates to groundwater. The other one-third is used indoors and is subsequently routed to local water reclamation plants (WRPs) and then to the Santa Clara River (after treatment). A portion of this water flows downstream out of the basin, and a portion infiltrates to groundwater.

Records show that groundwater levels and the amount of groundwater in storage were similar in both the late 1990s and the early 1980s, despite a significant increase in the urbanized area during these two decades. This long-term stability of groundwater levels is attributed in part to the significant volume of natural recharge that occurs in the streambeds, which do not contain paved, urban land areas. On a long-

term historical basis, groundwater pumping volumes have not increased due to urbanization, compared with pumping volumes during the 1950s and 1960s when water was used primarily for agriculture. Also, the importation of SWP water is another process that contributes to recharge in the Valley. In summary, urbanization has been accompanied by long-term stability in pumping and groundwater levels, plus the addition of imported SWP water to the Valley, which together have not reduced recharge to groundwater, nor depleted the amount of groundwater that is in storage within the Valley.

## c. Water Purveyors in Santa Clarita Valley and Their Service Areas

### (1) Castaic Lake Water Agency

For most residents within the Santa Clarita Valley, domestic water service is provided by four retail water purveyors: Los Angeles County Waterworks District 36, Newhall County Water District, Santa Clarita Water Division of CLWA and Valencia Water Company. However, these four retail water purveyors actually obtain all or a portion of their water supplies from the Castaic Lake Water Agency.

CLWA was formed in 1962 as a wholesale water agency for the purpose of contracting with the California Department of Water Resources (DWR) to provide a supplemental supply of imported water from the State Water Project (SWP) to serve retail water purveyors in the Santa Clarita Valley.[7] CLWA is one of 29 agencies with long-term water supply contracts with DWR for SWP water.[8] CLWA obtains SWP water from the upper reservoir at Castaic Lake, a storage reservoir of the SWP. CLWA serves the City of Santa Clarita, the unincorporated Santa Clarita Valley in Los Angeles County and portions of Ventura County. CLWA's service area covers approximately 195 square miles. **Figure 4.8-8** depicts CLWA's service area.

CLWA's physical water delivery system is comprised of facilities needed to treat and convey SWP supplies to the retail water purveyors. The funding for CLWA's expansion, modification, and addition to its current facilities and programs is through its Capital Improvement Plan (CIP). As part of CLWA's annual budget process, the CIP is reviewed and updated as necessary. An integral part of CLWA's CIP is its capital facilities fee, or development impact fee, which is a source of revenue to fund additional facilities and programs required to accommodate growth within the service area. As part of CLWA's CIP, funding has been established to provide for the purchase of additional imported supplies, implementation of reclaimed water (also referred to as "recycled water") programs and enhancement of groundwater, as well as groundwater banking/conjunctive-use programs both inside and outside the

7 See, California Water Code Appendix Sections 103-1, 103-15.

8 CLWA also provides retail water service through a contract with the Santa Clarita Water Division of CLWA since September 1999.





CLWA service area. According to CLWA, implemented over time, these measures will provide assurance that there will be sufficient supplies to meet water demands. Seawater and local brackish water desalination coupled with other contractual water exchanges could also provide the additional water supplies to meet anticipated community needs. It should be noted that desalination water would not likely be delivered to the Santa Clarita Valley. Desalination water would be exchanged for non-desalination water owned by another water agency located nearer to the desalination source. According to CLWA, the priority for implementation of some of these supply approaches will be driven in part by the relative cost. CLWA has also recently prepared a draft document entitled, Draft Report, Water Supply Reliability Plan, dated September 2003. A copy of this document can be found in Appendix 4.8 of this EIR. As indicated in the Draft Report, Water Supply Reliability Plan (also referred to as the Draft Water Supply Reliability Plan), SWP supply is variable due to its dependence on hydrology (i.e., precipitation and snowpack of the present and past years) and, therefore, deliveries can be curtailed. When sufficient SWP water is not available, the balance of the Valley's demand is met with local groundwater provided by the Santa Clarita Valley Water Purveyors. In recognition of the need to evaluate the technical, environmental, and economic issues associated with potential water supply reliability projects, CLWA has developed the long-term Draft Water Supply Reliability Plan. Because available groundwater is limited, it is anticipated that water demands will increasingly rely on SWP supplies. As CLWA's water requirements utilize increased proportions of its SWP Table A Amount, water banking opportunities, together with water transfers, water conservation, recycled water, and local Aquifer Storage and Recovery, become important elements of CLWA's long-term water supply strategy and are included in its Capital Improvement Program. In particular, water banking programs are essential to optimizing the use of CLWA's SWP Table A Amount.

The primary objectives of the Draft Water Supply Reliability Plan are to develop a protocol to identify current opportunities, evaluate opportunities using uniform economic criteria, and recommend a water supply reliability plan that focuses CLWA's efforts on the cost effective and beneficial opportunities.

The Draft Water Supply Reliability Plan includes the following primary elements:

- Near-term acquisition of water banking capacity to allow banking of excess SWP water until the selected long-term banks have been developed.
- Acquisition of water banking capacity south of the Tehachapi Mountains to provide reliability for potential SWP conveyance disruptions.
- Acquisition of water banking capacity north of the Tehachapi Mountains to meet the additional identified water banking requirements not provided south of the Tehachapi Mountains.

The Draft Water Supply Reliability Plan also includes a discussion of key implementation issues and a recommended implementation plan. The plan recommends that CLWA provide a minimum storage capacity of 50,000 acre feet by 2005, rising to 183,000 acre feet by 2050. Recent experience illustrating that CLWA is already participating in such programs comes from the Semitropic Water Storage District (Semitropic) in Kern County. Semitropic is expanding its existing groundwater banking program to include the Stored Water Recovery Unit (SWRU). The SWRU will provide 650,000 AF of additional groundwater storage capacity. CLWA has contracted with Semitropic to participate in this phase of the program. As part of this program, up to 50,000 AF of guaranteed annual recovery capacity could be made available to CLWA immediately. In 2002, CLWA fulfilled the following accomplishments in order to enhance, preserve, and strengthen the quality and reliability of existing and future supplies.

- Stored 24,000 AF of SWP water in the Semitropic Water Storage District's Groundwater Bank.
- Completed preliminary design for expansion of Earl Schmidt Filtration Plant from 25 mgd to 55 mgd.
- Obtained permission from California Department of Health Services to increase filter flow rate at ESFP.
- Negotiated with DWR, in conjunction with other State Water Contractors, an extended carry-over program for 2002 SWP allocations.
- Constructed Phase 2 of the Magic Mountain pipeline.
- Initiated construction of Lost Canyon Turnout for Newhall County Water District.
- Continued implementation of programs recommended in the UWMP adopted in December 2000.
- Continued implementation of the water conservation Best Management Practices, as recommended in the 2000 UWMP.
- Worked with other State Water Contractors to establish claim to 16,000 acre feet of SWP Table A subject to conditioned release by the Kern County Water Agency and DWR, following appropriate environmental review.
- Purchased site for location of Pumping Station for the Sand Canyon Pipeline and Reservoir project.
- Continued litigation against Whittaker et al., relative to the perchlorate contamination of groundwater supply, which impacts operation of 5 wells that can supply 8,700 gpm of pumping capacity.
- Continued cooperative effort with the U.S. Army Corps of Engineers for characterization studies of the Whittaker site.
- Participated in a task force effort with the City of Santa Clarita, area elected officials and state agencies to affect the cleanup and remediation of all aspects of the Whittaker site, including the perchlorate groundwater contamination.
- Began construction of the first phase of the recycled water transmission system.

For additional related information, please see the plan in Appendix 4.8.



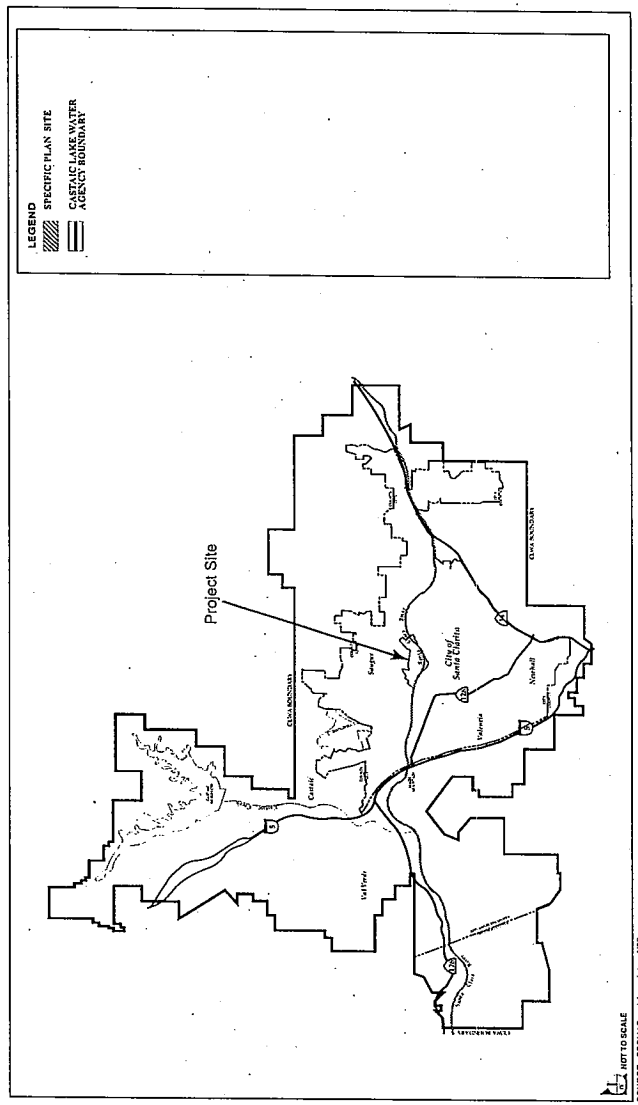


FIGURE 4.8-8
Castaic Lake Water Agency Service Area

CLWA's existing water delivery system is presented in **Figure 4.8-9**. As shown in that figure, CLWA owns and operates two water filtration plants, the Earl Schmidt Filtration Plant, with a current water capacity of 33 million gallons per day (mgd), and the Rio Vista Water Treatment Plant, with a water capacity of 30 mgd. The two plants have a current capacity to treat a total of 63 mgd. These plants were designed to accommodate expansion as required. CLWA has completed the design of the Earl Schmidt plant expansion to increase the plant's treatment capacity to a total of approximately 56 mgd. Construction of the treatment plant began in August 2003 and is scheduled to be on-line by mid-2005. CLWA also owns and operates an intake pump station at the Earl Schmidt plant, a pump station at the Rio Vista plant, major water transmission lines, and storage tanks and reservoirs. CLWA has also begun the design and environmental review process for expanding the capacity of the Rio Vista Water Treatment Plant from 30 mgd to 60 mgd.

CLWA treats the SWP water at its two water filtration plants and then distributes the water to the local retail water purveyors in the Santa Clarita Valley. From CLWA's two existing plants, the treated SWP water is delivered by gravity to the retail water purveyors through CLWA's distribution network of pipelines and turnouts. Local water retailers, such as CLWA's Santa Clarita Water Division, combine SWP water with groundwater from their own municipal-supply wells in the Alluvial Aquifer and Saugus Formation to meet water demand within their respective service areas. The actual mix between SWP and groundwater distributed by the water retailers to their respective service areas is variable over time and is based upon availability and operational and cost considerations.

CLWA's current total maximum contracted water allocation of SWP water is 95,200 AFY.[9] Of that amount, CLWA obtained 41,000 AFY from KCWA, through its member district Wheeler Ridge-Maricopa Water Storage District (Wheeler Ridge), pursuant to a March 1999 water transfer agreement. CLWA analyzed the potential environmental impacts of the water transfer in a Final EIR entitled, Supplemental Water Project Environmental Impact Report, dated February 1999 (SCH No. 98041127) (the CLWA EIR). A project opponent filed a petition for Writ of Mandate in April 1999, challenging the adequacy of the CLWA EIR under CEQA. The trial court rejected the petition, finding that the CLWA EIR complied with CEQA, and the petitioner appealed.

In a decision issued in January 2002, the appellate court reversed the trial court's judgment but not on any of the specific grounds urged by the petitioner. Rather, the appellate court found that, since the appeal had been filed, another EIR, which studied the environmental effects of the Monterey Agreement (the

9 An acre-foot represents 43,560 cubic feet, or 325,850 gallons, of water. An acre-foot of water has been generally defined as "an irrigation-based measurement equaling the quantity of water required to cover an acre of land to a depth of one foot." See, *Brydon v. East Bay Mun. Utility Dist.* (1994) 24 Cal.App.4th 178, 182, fn. 1.





Monterey Agreement EIR), had been ordered decertified (detailed information regarding the Monterey Agreement is provided in the heading below entitled **Imported SWP Water Supplies**. Because it found that the CLWA EIR had "tiered" on the now-decertified Monterey Agreement EIR, the appellate court held that the CLWA EIR also must be decertified. Notably, the appellate court found that, were it not for the intervening decertification of the Monterey Agreement EIR, it "...would have affirmed [the trial court's] judgment." See, *Friends of the Santa Clara River v. Castaic Lake Water Agency* (2002) 95 Cal.App.4th 1373, 1387.

Importantly, although the appellate court ordered the CLWA EIR decertified, it did *not* order CLWA to void its approval of the water transfer agreement itself. Instead, the appellate court remanded the matter to the trial court for further proceedings concerning the remedy, stating that the trial court was in a "better position" than the appellate court to make the factual determinations necessary to devise an appropriate remedy. Id. at 1388.

The trial court held a hearing on September 24, 2002, to hear argument on whether the water transfer agreement should be allowed to remain intact while CLWA completes a new EIR. As directed by the appellate court, the trial court ordered CLWA to vacate its certification of the CLWA EIR. However, the trial court did not order CLWA to vacate its approval of the water transfer agreement itself. Rather, the court ruled that CLWA may utilize and rely on the 41,000 AFY. The trial court allowed that the petitioner may renew its application for a prohibition on CLWA's use of the 41,000 AFY if the petitioner could provide evidence that CLWA is actually using the additional entitlement for purposes the petitioner considers improper. A copy of the trial court's judgment and Writ, along with a transcript of the September 24, 2002 hearing, is provided in **Appendix 4.8** to this report.

CLWA is currently in the process of preparing a new EIR for the water transfer agreement, consistent with CEQA and the appellate court opinion. CLWA has hired an environmental consultant and the work on the new EIR is well underway.

**(2) Retail Water Purveyor Service Areas**

CLWA and the four retail water purveyors provide water to most residents of the Santa Clarita Valley. A description of the service areas of the local retail purveyors is provided on the following pages.

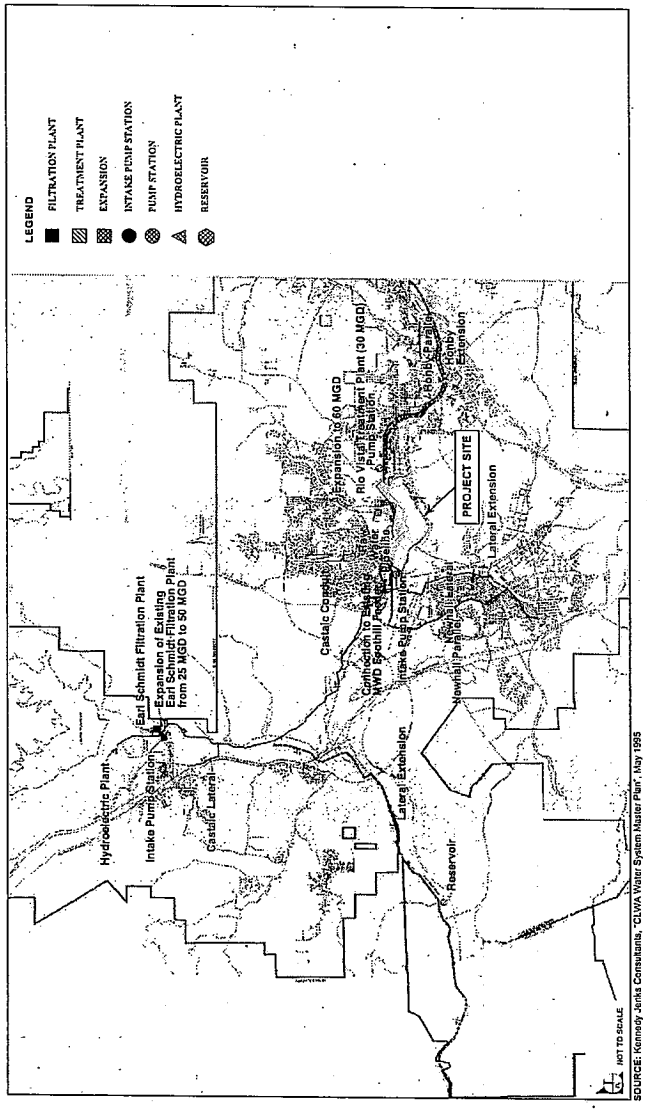


FIGURE 4.8-9
Castaic Lake Water Agency Water Delivery System



**The Los Angeles County Waterworks District 36** service area encompasses approximately 7,635 acres in the Hasley Canyon area and the unincorporated community of Val Verde. The District obtains its full water supply from CLWA turnouts. The District presently has no operating groundwater extraction facilities.

**The Newhall County Water District** service area lies within four distinct geographical areas of the Santa Clarita Valley: Newhall, Pinetree, Tesoro Del Valle, and Castaic. The district's service connections are located over a 34 square-mile area. The District's water supplies are obtained from groundwater wells and SWP water from CLWA turnouts.

**CLWA's Santa Clarita Water Division (SCWD)** service area includes portions of the City of Santa Clarita, including the proposed project site, and unincorporated portions of Los Angeles County in the communities of Saugus, Canyon Country and Newhall. SCWD is expected to be the retail water purveyor for the project.

In September 1999, CLWA acquired the Santa Clarita Water Company, an investor-owned retail water company serving the eastern part of the Santa Clarita Valley.[10] The former Santa Clarita Water Company was incorporated into CLWA's Santa Clarita Water Division, which continues to serve the same area with Santa Clarita Water Company's facilities. **Figure 4.8-10** illustrates the service area of the Santa Clarita Water Division (SCWD).

As buildout of the project proceeds over time, the tentative subdivision map would require preliminary and final water plans for review and approval by the SCWD. The plans would indicate anticipated water demand, required water storage facilities, booster pump stations, and on-site and off-site piping needed for adequate domestic and fire water flow pressure to the site. The company's water supplies are obtained from groundwater wells and SWP water from CLWA turnouts.

**The Valencia Water Company** service area serves a portion of the City of Santa Clarita and the unincorporated communities of Castaic, Newhall, Saugus, Stevenson Ranch and Valencia in Los Angeles County. Valencia's service area is approximately 25 square miles. Valencia's water supplies are obtained

10 CLWA acquired 100 percent of the capital stock in Santa Clarita Water Company by way of a judgment in eminent domain in Los Angeles County Superior Court case number BC 215065, entered on September 2, 1999. Subsequently, CLWA's authority to own the Santa Clarita Water Company and to provide retail water service through the former assets of the Company has been challenged in *Klajic v. Castaic Lake Water Agency* (California Court of Appeal, 2nd Dist, case number B161069). In addition, the public agency borrowing undertaken by CLWA to finance the acquisition of the Santa Clarita Water Company has been challenged in *Plambeck v. Stone and Youngberg* (LASC case no. BC249168). The cases are currently pending, but neither case seeks relief affecting the availability of water to Santa Clarita Water Company, SCWD or CLWA.

from groundwater wells and SWP water from CLWA turnouts. **Figure 4.8-11** illustrates the respective service areas of CLWA and the four retail water purveyors in the Santa Clarita Valley.

As of 2002, the four retail water purveyors service over 58,000 connections in the Santa Clarita Valley. The specific breakdown by purveyor is provided in **Table 4.8-2**.

**Table 4.8-2**
**Santa Clarita Valley Retail Water Purveyors**

| Purveyor | Connections |
|---|---|
| Los Angeles County Waterworks District 36 | 1,060 |
| Newhall County Water District | 7,700 |
| Santa Clarita Water Division of CLWA | 24,175 |
| Valencia Water Company | 25,286 |
| Total | 58,221 |

*Source: Santa Clarita Valley Water Report, 2002.*

**(4) CLWA's Allocation of Imported Water Supplies**

CLWA's fixed-percentage allocation to retail purveyors is based on a "first-come, first-served" allocation method. CLWA distributes imported water supplies among "water service areas" established by CLWA on a basis that allows imported water to be delivered to these areas where it is needed. CLWA's current allocation system, defined by Section 103-29.5 of CLWA's governing act as interpreted by CLWA, is based on the collection of developer impact fees paid by new development and other contributions collected within each "water service area." Under CLWA's allocation method, water supplies available to CLWA are allocated among the CLWA-defined "water service areas" based on the payment of developer impact fees, property taxes, and other contributions that fund CLWA's Capital Program. Historically, however, CLWA has not been required to allocate imported water supplies to the retail water purveyors, because the available supply of imported water has been sufficient to meet all purveyor requests. Even in the extreme drought year, 1991, no allocation was necessary, because the four retail purveyors entered into a water sharing agreement by which the purveyors shared all available water supplies and, with the help of significant conservation, were able to meet all water demand in the Santa Clarita Valley. Accordingly, absent the need for an allocation during times of limited supply under CLWA's method, CLWA supplies are delivered to retail water purveyors on a first-come, first-served basis. However, should CLWA need to allocate water resources, SCWD's allocation would likely increase due to the increased amount of connection fees paid to CLWA.



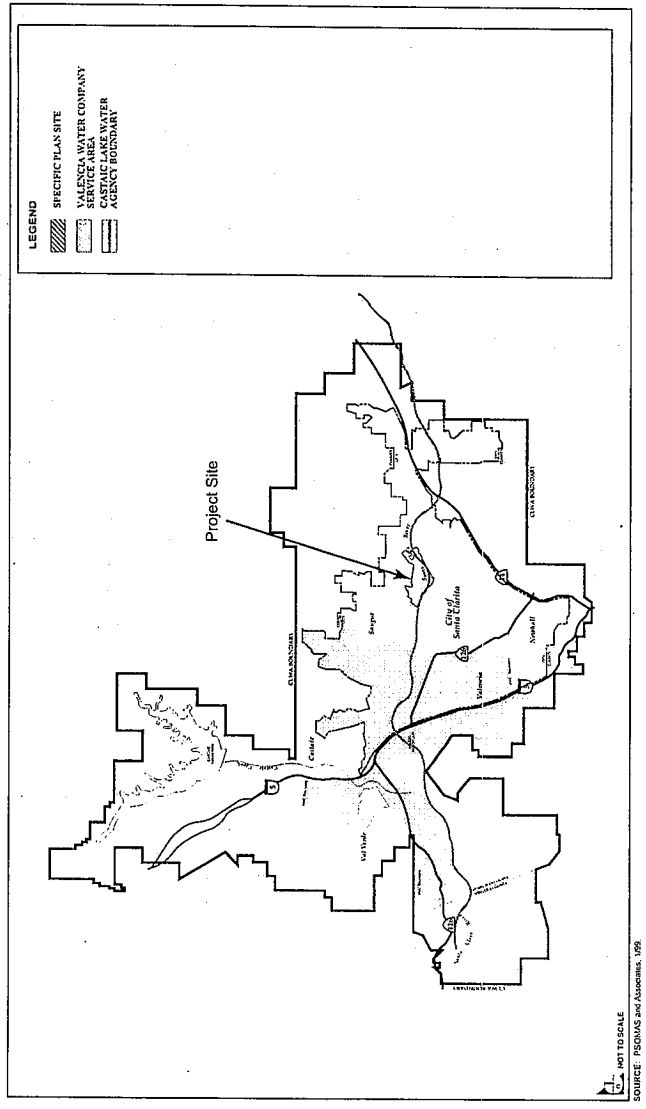


FIGURE 4.8-10
Valencia Water Company Service Area

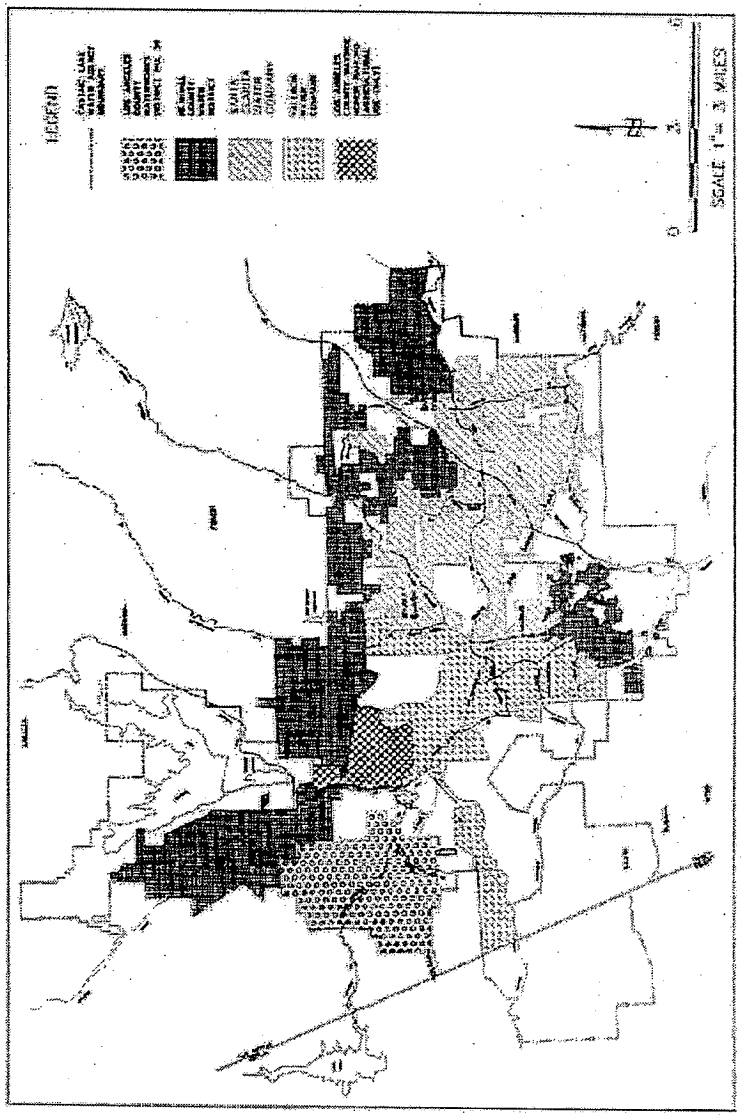


FIGURE 4.8-11 Groundwater Basins in the Santa Clara River Drainage

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In light of CLWA's allocation method, SCWD expects that its share of water supplies from CLWA is expected to increase for the following reasons: (a) SCWD's "water service area" includes significant amounts of existing and planned development; (b) water supplies are now allocated among CLWA-defined "water service areas," and SCWD's "water service area" significantly contributes to the funding of the CIP; and (c) water supplies are delivered by CLWA to the purveyors, including the SCWD, on a first-come, first-served basis. Accordingly, SWP water supplies in the Santa Clarita Valley are evaluated on a valley-wide basis, rather than on individual percentage allocations to retail purveyors.

(5) Santa Clarita Valley Water Purveyors

The wholesale and retail water purveyors in Santa Clarita Valley meet regularly as a technical group to coordinate the water resources of the Valley. The group has been commonly known as the Santa Clarita Valley Water Purveyors (purveyors). One of the highest priorities of this group is to provide an adequate water supply for the CLWA service area, safeguard existing water resources and develop both short-term and long-range plans for the efficient use of water in the Santa Clarita Valley.

Over the years, the purveyors have documented the availability of water resources in the region, assessed the condition of the local groundwater aquifers and their hydrogeologic character and reviewed aquifer storage capacity and the perennial yield and recharge rate of the aquifers. The purveyors have also studied the potential for conjunctive use of both groundwater and imported water resources. In addition, the purveyors continue to monitor water quality, including plans for the treatment of water to maintain good quality water for use in the Santa Clarita Valley.

Other cooperative efforts of the purveyors have included development of drought contingency plans, evaluation of landfill impacts on the groundwater basin, coordination of emergency response procedures and implementation of valley-wide conservation programs. In 1985, the purveyors prepared the area's first UWMP. In 1998, the purveyors participated with CLWA in the preparation of a Draft Integrated Water Resources Plan (IWRP), which assessed the existing and long-term water supply and demand of the Santa Clarita Valley. In addition to identifying the range of water demands and supplies, the IWRP addressed opportunities to improve water supply reliability for the Santa Clarita Valley. The plan suggested a phased approach toward development of the supplies needed to meet projected demands. This approach combined additional acquisition of imported water, water conservation, surface and groundwater storage, water transfers and exchanges and water reclamation in an integrated strategy designed to meet increasing water demands while assuring a reasonable degree of supply reliability.

In years 1998 through 2003, the purveyors prepared Annual Water Reports (also referred to as "water reports") providing information about the local water supplies and water demands in Santa Clarita Valley. The information presented in the water reports is intended to supplement information already required by the County's Development Monitoring System (DMS). The DMS is used by both the County and the City of Santa Clarita to track development activity in the Santa Clarita Valley, and it requires that adequate water supplies be in place prior to development taking place. The information presented in the water reports is used by the County and City of Santa Clarita in connection with future land use decisions in the Santa Clarita Valley in general.

In addition, in December 2000, the Santa Clarita Valley's water agencies jointly sponsored preparation of the 2000 UWMP. The UWMP covers the CLWA service area, which includes the service areas of the four retail water purveyors. The UWMP presents information about the water supply, water demand, water reclamation (also referred to as "water recycling"), water conservation and reliability planning in the CLWA service area over a 20-year time frame. Consultants with expertise in water resource management were retained to assist CLWA and retail water purveyors in preparing the UWMP.

In April 2001, opponents of the UWMP filed a lawsuit against CLWA and the retail water purveyors challenging the adequacy of the UWMP under the Urban Water Management Planning Act and the Public Trust doctrine. CLWA and the purveyors successfully demurred to the Public Trust doctrine claim and the trial court ordered the claim dismissed. The trial court also ruled that the UWMP is adequate. A copy of the court's decision is attached to this report as **Appendix 4.8**. Petitioners have appealed this ruling.

The Santa Clarita Valley Water Purveyors have adopted resolutions approving the UWMP. The State Department of Water Resources (DWR) has also accepted the UWMP for filing. In addition, DWR indicated in its review that the Santa Clarita Valley Water Purveyors had addressed virtually all of the requirements of the Urban Water Management Planning Act, including all of the more significant provisions relating to water supply, demand, and reliability. Accordingly, the UWMP is considered by CLWA and the SCWD to be in compliance with the Urban Water Management Planning Act. Whatever the outcome of the UWMP litigation, however, it is not expected to have any impact on the validity of this water resources analysis. The bulk of the UWMP data utilized in this report relates to aspects of the plan not challenged in the current litigation. Moreover, all of the data cited in this report is provided for informational purposes only and has been independently reviewed and considered by the City of Santa Clarita prior to use in this analysis. State law requires that UWMPs be updated every five years.





(6) Water Reclamation Plants in the Santa Clarita Valley

Most existing wastewater generated in the Santa Clarita Valley is treated at two WRPs. The two plants are operated by the County Sanitation Districts of Los Angeles County (CSDLAC).

The Saugus WRP, a tertiary treatment plant, is located southeast of the intersection of Soledad Canyon Road and Bouquet Canyon Road. The Valencia WRP, also a tertiary treatment plant, is located on The Old Road, north of Magic Mountain Parkway. The two facilities are illustrated in **Figure 4.8-12**. The Saugus WRP, located in District No. 26, has a permitted capacity of 6.5 mgd.

The Valencia WRP, in District No. 32, is presently undergoing expansion of an additional 9 mgd, which will be completed in 2003. Once constructed, the permitted capacity of the Valencia WRP is anticipated to be 21.6 mgd.

These two WRPs have been interconnected to form a regional treatment system known as the Santa Clarita Valley Joint Sewerage System (SCVJSS). The relationship between the two districts was established through a joint powers agreement that created the regional treatment system and permits the Valencia WRP to accept flows that exceed the capacity of the Saugus WRP.

Due to site space constraints, the Saugus WRP, completed in 1962, will not be expanded beyond its current permitted capacity of 6.5 mgd. In 2002, the Saugus WRP had an average monthly effluent flow of 5.60 mgd (6,294 AFY), which is approximately 86 percent of its permitted capacity. Effluent from the Saugus WRP contains about 723 milligrams per liter TDS (total dissolved solids) and is discharged to the Santa Clara River west of Bouquet Canyon Road.

The Valencia WRP, completed in 1967, has a current permitted capacity of 12.6 mgd. The ultimate planned capacity for the Valencia WRP is 27.6 mgd. In 2002, the average monthly effluent flow for the Valencia WRP was 12.11 mgd, which is approximately 96 percent of its current permitted capacity. Effluent from the Valencia WRP is discharged to the Santa Clara River west of The Old Road.

It should be noted that the Newhall Ranch Specific Plan proposes a new 6.9 mgd WRP on the Newhall Ranch site to exclusively serve the Specific Plan. The proposed Newhall Ranch WRP would be located near the western edge of the Specific Plan site along the south side of State Route 126 (SR-126). Effluent from the proposed Newhall Ranch WRP would be used to partially meet non-potable water demands within the Specific Plan site.

For further information regarding use of reclaimed water from the existing WRPs and the proposed Newhall Ranch WRP, please refer to the section below.

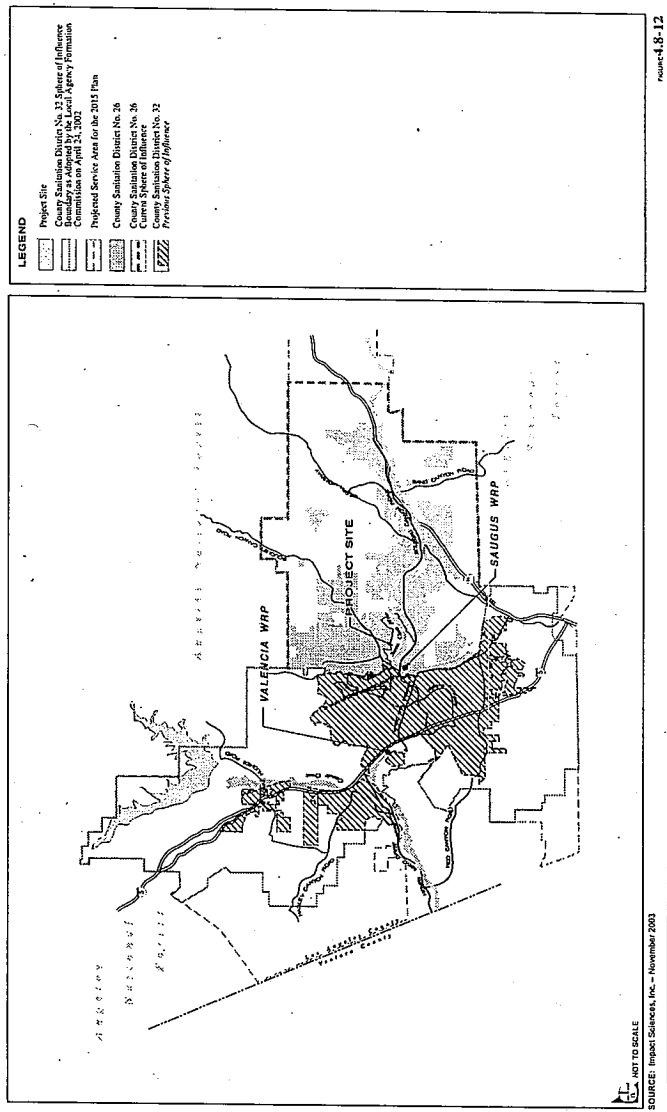



FIGURE 4.8-12

Existing Water Reclamation Plants and Sanitation Districts

## 2. WATER SUPPLIES AND DEMAND IN THE SANTA CLARITA VALLEY

### a. Preface

This section provides important regional information regarding available water sources for the Santa Clarita Valley, including the project site. The section summarizes two important aspects of the water picture, which provide context to the water supply and demand analysis of the project. First, the section summarizes the existing and planned future water supplies for the Castaic Lake Water Agency (CLWA) service area, including the project site. Second, the section summarizes the historic, existing and projected water demands within the CLWA service area.

Historically, local groundwater extracted from the Alluvial Aquifer and Saugus Formation has been the primary source of water in the Santa Clarita Valley. However, since 1980, local groundwater supplies have been supplemented with imported water from the SWP. These current water supplies are described in this section.

This section also briefly describes the groundwater resources of the Santa Clarita Valley and SWP water supplies, including reclaimed water, groundwater banking supplies, water transfers and desalted water. In addition, in recent years, water conservation has become an increasingly important factor in water supply planning. In a dry year (i.e., a year of below average rainfall) following a year of average or normal rainfall, experience in the Santa Clarita Valley indicates that the demand for water typically increases by approximately 10 percent. For example, in a dry year a homeowner may notice that his or her lawn is drying out during the winter months, a time of year when people normally decrease lawn sprinkler use to take advantage of winter rains. In response, the homeowner increases sprinkler use in the winter to compensate for reduced rainfall. This type of action causes water demand to increase in a dry year when compared with years of average or above average rainfall. Conservation planning is a required component of the UWMP prepared by the water purveyors in the Santa Clarita Valley. Water purveyors expect that during a critical dry year, or during a prolonged drought, water demand can be reduced by up to 20 percent below the single dry year demand. This is due to the fact that during such critically dry periods, purveyors are able to enact voluntary and mandatory water conservation programs (however, this analysis conservatively assumes that critical dry year demand would decrease by 10 percent below dry year demand). This section describes the UWMP's current drought contingency planning for the Santa Clarita Valley.





### b. Local Groundwater Supplies

Prior to 1980, local groundwater extracted from the Alluvial Aquifer and the Saugus Formation was the primary water source for the Santa Clarita Valley. The current capacities and future potential of these Aquifers are discussed below, including the reliance on these sources during drought periods. The groundwater information presented below is based on: (a) a report prepared by Slade entitled, 2001 Update Report Hydrogeologic Conditions in the Alluvial and Saugus Formation Aquifer Systems, dated July 2002; (b) a 2-volume report prepared by Richard C. Slade & Associates (Slade) entitled, Hydrogeologic Investigation of the Perennial Yield and Artificial Recharge Potential of the Alluvial Sediments in the Santa Clarita Valley of Los Angeles County, California, dated December 1986; (c) a 2-volume report prepared by Slade entitled, Hydrogeologic Assessment of the Saugus Formation in the Santa Clarita Valley of Los Angeles County, California, dated February 1988; (d) a technical memorandum prepared by Slade, dated November 16, 2000; (e) a letter from Joseph C. Scalmanini, Luhdorff and Scalmanini Consulting Engineers, dated December 15, 2000, regarding review of the groundwater components of the UWMP; (f) a report prepared by Slade entitled, Assessment of the Hydrogeologic Feasibility of Injection and Recovery of Water in the Saugus Formation, Santa Clarita Valley, California, dated February 2001, including the Technical Appendix by Slade entitled, Hydrogeologic Conditions in the Saugus Formation, Santa Clarita Valley, California, February 2001; (g) a report prepared by $CH_2MHill$ entitled, Newhall Ranch ASR Impact Evaluation, dated February 2001; and (h) a report prepared by $CH_2MHill$ entitled, Newhall Ranch Updated Water Resources Impact Evaluation, dated September 2002.

As stated above, the groundwater basin underlying the CLWA service area consists of two aquifers comprised of the Alluvial Aquifer and the deeper underlying Saugus Formation (See previous, **Figure 4.8-4**). The two aquifers occupy approximately 84 square miles in the central portion of CLWA's service area.

The geologic sediments in the Alluvial Aquifer and the underlying Saugus Formation have been assessed according to their relative water-bearing characteristics. The term "water-bearing characteristics" means the relative ability of the geologic materials to contain, transmit and yield groundwater to wells. As such, two geologic divisions are recognized in the Santa Clarita Valley: a water-bearing sediment group and a nonwater-bearing rock group. Depending upon water levels, the water-bearing sediments are capable of becoming saturated, which allow the sediments to provide water that can be extracted by pumping through wells. As such, the sediments in these aquifers constitute the "groundwater reservoir" in the Santa Clarita Valley.

The water-bearing sediments have been penetrated to various depths by numerous water wells in the region and historically have provided virtually all of the groundwater extracted in the Santa Clarita Valley. Underlying the water-bearing sediments is the relatively impermeable, nonwater-bearing bedrock.

Figure 4.8-4 illustrates the water-bearing sediments in the Alluvium (shown as map symbol, Qal), in the terrace deposits (shown as Qt) and in the geologically older sediments known as the Saugus Formation (shown as QTs). For the most part, the water-bearing sediments are geologically younger, more permeable, less consolidated and less structurally deformed than the underlying relatively impermeable, nonwater-bearing bedrock.

**(1) Alluvial Aquifer**

The water-bearing sediments in the Santa Clarita Valley consist of the alluvial or valley fill deposits that underlie the Santa Clara River and its tributaries. Typically, the Alluvial Aquifer tends to be the deepest along the central portion of the river, and thins or pinches-out as the flanks of the adjoining hills are approached. The maximum thickness of the Alluvial Aquifer varies in the Santa Clarita Valley, but is generally considered to be approximately 200 feet. (Slade 2002) The Alluvium is able to produce good quality water where saturated.

Groundwater present in the alluvial deposits in the Santa Clarita Valley is unconfined. Natural sources of recharge to the Alluvium include deep percolation of direct precipitation; infiltration of stream runoff flowing into the valley along the Santa Clara River and its tributaries; subsurface inflow from the adjoining (upgradient) portions of the Alluvial Aquifer to the north and east of the Santa Clarita Valley; and discharge of groundwater from the Saugus Formation to the Alluvial Aquifer on the west side of the Santa Clarita Valley.

Man-made sources of recharge to the Alluvial Aquifer include deep percolation of irrigation seepage; percolation of stormwater runoff from urban areas; percolation of surface flow and underflow from Castaic Dam in the Castaic Creek area; percolation of water released by the Los Angeles Department of Water and Power from its reservoir facilities in Dry Canyon and upper Bouquet Canyon; and percolation of discharges to the Santa Clara River from the existing WRPs.

Outflow or discharge from the Alluvial Aquifer occurs by water well extractions. Additional discharge occurs by subsurface outflow through the Alluvial Aquifer to the downstream Piru groundwater basin to the west, and by seepage to underlying permeable portions of the Saugus Formation, particularly in the



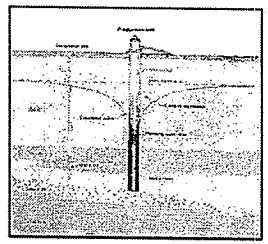


eastern portion of the basin. Discharge also occurs by evapotranspiration in areas where deep-rooted riparian vegetation grows along the main Santa Clara River channel, particularly along the western reach of the river.

Available aquifer test data from alluvial wells indicate that the Alluvial Aquifer is unconfined (i.e., Aquifer is under water table conditions). Transmissivity values range from 35,000 to over 400,000 gallons per day per foot and specific yield values range from about 0.09 to 0.16. (Slade 1986)

As to the municipal-supply water well extraction from the Alluvial Aquifer, the Newhall County Water District (NCWD), the Santa Clarita Water Division of CLWA (SCWD) (formerly the Santa Clarita Water Company), Valencia Water Company (VWC) and the Wayside Honor Rancho (WHR) own and operate municipal-supply wells and extract water from this Aquifer. The Newhall Land and Farming Company also owns and operates private agricultural-supply wells and extracts water from this Aquifer.[11] Figure 4.8-13 illustrates a typical well configuration.

**Figure 4.8-13**
**Typical Well Configuration**



Groundwater levels in the Alluvial Aquifer have varied over the period of available record, reflecting changes in pumping and variations in the amount of recharge and discharge.[12] Because of the generally high permeability of the Alluvium and the hydraulic interrelationship between the Alluvial Aquifer and

11 The wells identified above do not include pumping of water from this aquifer by other privately-owned industrial, agricultural, ranch or domestic-supply wells. Production of water from these other wells is estimated to be 500 AFY.

12 Available records generally extend back to the 1950s, with some data available from about 1930 to 1947.

the Santa Clara River and its tributaries, groundwater levels may rapidly fluctuate over the course of a year, and, to a large degree, in response to precipitation, runoff and groundwater pumping.

The amount of groundwater in storage in the Alluvium can vary considerably because of the effects of recharge and discharge from the Aquifer. Slade (2000) has estimated the historic quantity of water stored in the Alluvial Aquifer at 240,000 acre-feet following periods of high rainfall. The historical annual production of the Alluvial Aquifer is estimated to be between 30,000 to 40,000 AFY in normal/average rainfall years (Slade 2000; Scalmanini 2000). During dry years, the Alluvial Aquifer production should be reduced to the range of 30,000 to 35,000 AFY. (Slade 2000)

Based on the results of Slade (1986, 2000), and the operating experience of the Santa Clarita Valley water purveyors, Scalmanini (2000) addressed the sustainable yield of the Alluvial Aquifer and found that the range of pumping from the Alluvial Aquifer (30,000 to 40,000 AFY in normal/average years, and 30,000 to 35,000 AFY in dry years) is consistent with studies of the Aquifer and the successful operating experience of the Aquifer over the last 50 years:

> *"[T]he Alluvium has been managed within its perennial yield,*[13] *while pumping in the broad range of nearly 20,000 AFY to more than 42,000 AFY. Although there have been seasonal and longer term intermittent lowering of ground-water levels in response to both variations in pumping and variations in precipitation (and associated recharge), the long-term trend in Alluvial ground-water levels has been stable, with no persistent trend toward lower water levels and associated depletion of ground-water storage. While the cited ranges for Alluvial pumpage in various year-types suggest that, overall, the average extraction will be greater than the perennial yield reported by Slade in 1986, recent high Alluvial pumping and sustained high ground-water levels suggest that an updated perennial yield analysis would result in a higher value of perennial yield than that reported by Slade nearly 15 years ago. Ultimately, however, the exact number is not as important as operating in a range of production that does not cause undesirable results such as chronic ground-water level decline; [and] the ranges cited in the UWMP would certainly fit that criterion. In any case, in light of the range of historical pumping from the Alluvium and the lack of any chronic ground-water level depression as a result of that pumping, it appears sound to plan on long-term ground-water supplies from the Alluvium in the general ranges of pumping included in the UWMP, which are consistent with what has been successfully practiced over the last 50 years." (Emphasis added) (Scalmanini 2000)*

This information indicates that use of the Alluvium has occurred without adverse affects such as long-term water level decline or degradation of groundwater quality. The current management practice of the Santa Clarita Valley water purveyors is to prioritize the use of the Alluvial Aquifer because of the Aquifer's ability to rapidly recharge, store and produce good quality water on an annual basis. Like most

13 Perennial yield is defined as the maximum quantity of water that can be withdrawn annually from a groundwater resource under a given set of conditions without causing an undesirable result. The phase "undesirable result" is understood to refer to a gradual lowering of the groundwater levels resulting eventually in depletion of the supply, subsidence, increased energy costs, desiccated wetland or degraded water quality. Source: California Groundwater Management, Groundwater Resources Association of California, Steve Bachman, Carl Hauge, Kevin Neese, Anthony Saracino.





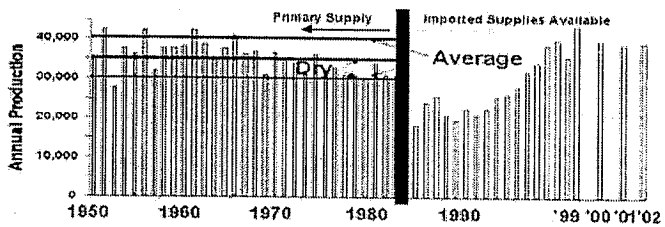
groundwater basins, it is possible to intermittently stress the Alluvial Aquifer (i.e., pump in excess of the perennial yield value for one or more years without long-term adverse effects). Short-term withdrawal in excess of the perennial yield may temporarily lower groundwater levels, however, subsequent decreases in pumping and natural recharge results in a rapid return of groundwater levels and associated refilling of groundwater storage with no harm to the resource. Historical groundwater data collected from the Alluvial Aquifer over many hydrologic cycles demonstrate that groundwater elevations return to normal in average or wet years following periods of abnormally low rainfall.

**(a) Historical and Current Conditions of the Alluvial Aquifer**

Over the last 50 years, groundwater production from the Alluvial Aquifer has ranged from 20,000 AFY to more than 40,000 AFY. Since the introduction of SWP supplies to the CLWA service area, total pumpage from the Alluvial Aquifer has ranged from a low of about 20,000 AFY (in 1983) to a high of 43,000 AFY (in 1999); average pumpage from the Alluvium over that period has been 28,500 AFY. Agricultural pumpage of the Aquifer throughout the 1950s was consistently in the range of 33,000 AFY to 41,000 AFY. (2002 Santa Clarita Valley Water Report, p. 15)

**Figure 4.8-14** depicts historical Alluvial Aquifer groundwater production from 1950 to 2002. The historical data and all technical information indicate that the Alluvial Aquifer is in good operating condition. The data and related information show that the Alluvial Aquifer has produced annually up to 43,000 AFY without any undesirable results (such as long-term water level declines or degradation of the water quality).

**Figure 4.8-14**
**Historical Groundwater Production – Alluvial Aquifer**



(b) Groundwater Levels in the Alluvial Aquifer

Based on available data, the groundwater levels over the last 20 years are generally higher than over the preceding 30 years. In some locations of the Alluvial Aquifer, there are intermittent dry-period declines (and an associated use of some groundwater from storage) followed by wet-year recoveries (and associated refilling of storage space). On a long-term basis, whether over the last 23 years since importation of supplemental SWP water, or over the last 40 to 50 years (since the 1950s–60s), the Alluvial Aquifer shows no trend toward decreasing water levels or storage decline (i.e., overdraft). Based on the available data, pumpage from the Alluvial Aquifer has been and continues to be within the operational yield of the aquifer. (2002 Santa Clarita Valley Water Report, pgs. 16 and 17)

(c) Groundwater Flows in the Alluvial Aquifer

In general, groundwater movement in the Alluvium beneath the side canyons is toward the east-west trending Santa Clarita Valley and then westward in the Alluvium toward the Los Angeles County/Ventura County line. This general pattern of groundwater flow in a westerly direction remains unchanged whether groundwater levels are high or intermittently depressed. This finding is based on an examination of Aquifer extent and historical groundwater levels. Long-term stream flow data gauged near the County line shows notably higher flows from the Santa Clarita Valley into the uppermost downstream basin, the Piru Basin, over the last 30 to 35 years. (2002 Santa Clarita Valley Water Report, page 29 and Figure III-6)

(d) Water Quality in the Alluvial Aquifer

**Total Dissolved Solids:** The principal water quality concern in waters from the Alluvial Aquifer is total dissolved solids (TDS). TDS concentrations in the Alluvial Aquifer typically range from 400 to 700 milligrams per liter (mg/l), and the water is considered moderately hard to hard. Groundwater quality variations also inversely correlate with precipitation and stream flow: Wet periods have produced substantial recharge of higher quality water (low TDS) and dry periods have resulted in an increase in TDS (and individual component constituents) in the deeper parts of the aquifer.

**Ammonium Perchlorate:** The water purveyors have tested municipal-supply water wells in the Alluvial Aquifer in response to claims that groundwater supplies in the Alluvium are contaminated from ammonium perchlorate. Perchlorate is used in the manufacture of rocket propellants, munitions and fireworks. The alleged source of perchlorate is a facility in the Santa Clarita Valley known as the Whittaker-Bermite site. Each local water purveyor regularly collects groundwater samples from the





numerous municipal-supply wells in the Alluvial Aquifer. In 2002, as part of ongoing monitoring of wells for perchlorate contamination, perchlorate was detected in one Alluvial well located near the former Whittaker-Bermite facility that has been the primary focus of potential perchlorate contamination that has impacted four Saugus wells since 1997. The detected concentration at the Alluvial well (up to 5.9 ug/l) slightly exceeded the Action Level for perchlorate (4 ug/l) and the well has been inactivated for municipal water supply. All other Alluvial wells operated by the Purveyors continue to be used for municipal water supply service (2002 Santa Clarita Valley Water Report, p. 17). The wells will continue to be sampled, tested and monitored for possible detection of perchlorate, and any other contaminants. The sampling, testing and monitoring of the numerous municipal-supply wells in the Alluvial Aquifer actually serve as an early warning device for the possible detection (and ultimate treatment) of perchlorate and other contaminants. For further information regarding perchlorate and other contaminants in the Santa Clarita Valley's other Aquifer, Saugus Formation, please refer to the section below.

(2) Saugus Formation

Underlying the Alluvial Aquifer in the main portion of the Santa Clarita Valley and extending to the surrounding foothills is the Saugus Formation. The Saugus Formation contains lenticular[14] and interfingered[15] beds of poorly- to well-consolidated sandstone, conglomerate, and siltstone that are at least 5,000 feet thick in the deepest part of the basin. The degree to which these beds are laterally continuous is unknown. However, interpretations of geophysical electric log data by Slade (2000) indicates that some more permeable sand zones may be laterally continuous from one end of the basin to the other. The deepest and oldest portion of the Saugus Formation was deposited in a marine environment (the Sunshine Ranch member) and consists of siltstone, shale, and fine-grained sandstone of low permeability.

Faulting and folding of the rocks in the region have caused the sedimentary rocks, including the Saugus Formation, to form a bowl-shaped structure. The Saugus Formation and the underlying bedrock dip generally toward the center of the "bowl" from all locations along the bottom (basal) contact of the Saugus Formation.

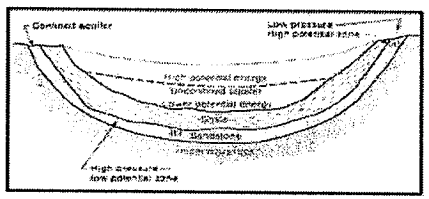
14 Lenticular: Shaped approximately like a double convex lens. When a mass of rock thins out from the center to a thin edge all around, it is said to be lenticular in form.

15 Interfinger: To grade or pass from one material into another through a series of interlocking or overlapping wedge-shaped layers.

Dominating the geologic structure in the project area is the northwesterly-trending San Gabriel Fault. A spur from this fault, referred to as the Holser Fault, trends west through the project area. South of the Faults, the Saugus Formation is thickest and this is the area where the majority of Saugus municipal water wells are located. North of the San Gabriel Fault, the Saugus Formation is older, thinner and finer grained than south of the Fault. Little groundwater development has occurred north of the San Gabriel Fault.

The Saugus Formation is recharged by two principal sources: (1) deep percolation of precipitation in the exposed portions of the Saugus Formation in the highlands surrounding the valley, and (2) seepage from the Alluvial Aquifer along the Santa Clara River and its tributaries, particularly on the eastern end of the Santa Clarita Valley. Minor recharge may also occur in limited areas through irrigation seepage where the land overlying the Saugus is cultivated. In the eastern part of the Santa Clarita Valley, the Saugus Formation is underlain by older, relatively impermeable rocks of the Castaic Formation and Mint Canyon Formation, which form the bottom and sides of the "bowl-shaped" Saugus structure. Little, if any, groundwater exchange occurs between these formations and the Saugus Formation (see **Figure 4.8-15**).

**Figure 4.8-15 Cross Section of Groundwater Basin**



The amount of water-bearing sediments in the Saugus Formation is substantial. Slade (2002) estimated that the amount of water stored in the Saugus Formation is approximately 1.65 million acre-feet. A determination of the perennial yield of the Saugus Formation has not been made because information on the Aquifer characteristics is limited. However, for planning purposes, the annual production of the Saugus Formation is estimated to be between 7,500 to 15,000 AFY in normal/average years and 21,000 to 35,000 AFY in dry years. (Slade 2000)

Discharge from the Saugus Formation occurs in part through groundwater extraction from wells as deep as 2,000 feet. Discharge from the Saugus Formation also occurs at the west end of the valley (west of the I-5 bridge) where Saugus groundwater is known to discharge to the Alluvial Aquifer. This discharge of





groundwater from the Saugus Formation into the Alluvial Aquifer is promoted in this area by the presence of older and relatively impermeable rocks of the Pico Formation that underlie and form the western boundary of the Saugus Formation (where they are exposed at the ground surface). These older rocks of the Pico Formation form a barrier to groundwater flow and force Saugus groundwater to discharge upwards into the Alluvial Aquifer approximately 2.5 miles upstream of the county line (refer to the previously presented **Figure 4.8-6**).

As a result of the folding of the Saugus, Pico, and Mint Canyon Formations in the Santa Clarita Valley, permeable sand layers in places within the Saugus Formation are oriented so that they are in direct connection with the overlying Alluvial Aquifer. Consequently, recharge to the Saugus may be greatest in these areas, particularly on the east side of the Santa Clarita Valley. Also, discharge to the Alluvium is enhanced where permeable sand layers of the Saugus are contacting the Alluvial Aquifer on the western end of the Santa Clarita Valley where the Saugus discharges.

Available Aquifer test data from Saugus wells located near the center of the Santa Clarita Valley where the Saugus is thickest indicate that the Saugus is semi-confined (under pressure). Transmissivity values range from 80,000 to 160,000 gallons per day per foot and storativity values are on the order of $10^{-3}$ to $10^{-4}$. In areas where the Saugus crops out, the uppermost-saturated zones are partially unconfined because the permeable beds are folded upwards. In the highlands, the Saugus beds are exposed at the ground surface, and in the valley the Saugus beds are in contact with the Alluvial Aquifer.

Based on the results of Slade (1988, 2000), and the operating experience of the water purveyors, Scalmanini (2000) undertook an independent review of the information regarding the Saugus Formation, and concluded that:

> *"The Saugus Formation is the more difficult of the two aquifers in the area to assess, both in terms of dry period water supply and long-time dependability, primarily because there is no historical operating experience in the range of dry-year Saugus pumping cited in the UWMP. The memorandum in Appendix C [Slade 2000] includes a brief discussion of historical pumpage (up to a maximum of nearly 15,000 AFY, and an average of slightly more than 7,000 AFY over the last 20 years), limited historical water levels (no long-term change or other evidence of overdraft, with current levels comparable to pre-development levels), and ground-water storage (on the order of one million AF in storage in the depth zone of 500 to 2,500 feet). Based on these conditions and a couple of other considerations (large areal extent and substantial vertical depth of the Saugus, and typically deep well completions with sufficient available drawdown in wells), it is concluded that it is hydrogeologically feasible to increase pumpage from the Saugus for short-term periods in a ramped manner from 15,000 to 25,000 to 40,000 AFY. The memorandum is not specific with regard to pumping outside the "short-term" periods when pumpage might be increased; however, it implies that increased pumpage would occur only during dry periods, and that pumpage would decline to lower values in wet and normal period such that the long-term stability in water levels and storage discussed in the memorandum would be maintained." (Emphasis added) (Scalmanini 2000)*

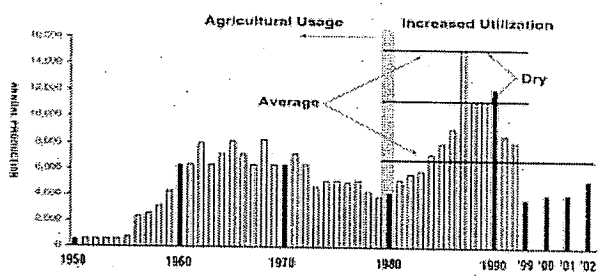
Focusing on the projected groundwater supplies depicted in the UWMP and whether those supplies were "realistic" under average and dry year conditions, Scalmanini (2000) concluded that:

> *"[B]oth the Alluvium and the Saugus are reasonable and sustainable sources at the yields represented in the Plan. As such, those yields are not overstated and will not deplete or "dry up" the ground-water basin; and there is no need to 'reduce' them for purposes of planning within the context of an Urban Water Management Plan." (Scalmanini 2000)*

**(a) Historical and Current Conditions of the Saugus Aquifer**

From 1980 through 2002, total pumpage from the Saugus Formation has ranged from a low of about 3,850 AFY in 1983 to a high of nearly 15,000 AFY in 1991. Average pumpage over that period has been nearly 6,800 AFY (2002 Santa Clarita Valley Water Report). Slade has estimated that the historical annual production of this Formation is 7,500 AFY to 15,000 AFY. (Slade 2000) Figure 4.8-16 depicts the historical groundwater production from the Saugus Formation from 1947 to 2002.

**Figure 4.8-16**
**Historical Groundwater Production from the Saugus Formation from 1947 to 2002**




Wells drilled into the Saugus Aquifer south of the San Gabriel Fault are anticipated to produce 1,500 to 2,000 gallons per minute, from a depth of 1,500 to 2,500 feet.





**(b) Groundwater Levels of the Saugus Aquifer**

Although there have been seasonable water level changes, in response to groundwater pumping, the long-term trend in the Saugus Aquifer (over the last 35 to 40 years) shows relatively stable groundwater levels (2002 Santa Clarita Valley Water Report [Figure III-3]). There is no trend toward a sustained decline in Saugus water levels or storage, which would be indicative of overdraft conditions. On that basis, and with recognition that historical (pre-1980) pumpage was quite small, and that average pumpage over the last two decades has been less than the reported range of potential recharge to the Saugus Aquifer, pumpage from the Saugus Aquifer has been and continues to result in the long-term stability of water levels and storage capacity.

Scalmanini (2000) has concluded that it is feasible to increase pumping from the Saugus for short-term periods in a ramped manner from 15,000 AFY to 25,000 AFY to 40,000 AFY based on: (a) historical pumping data; (b) the amount of groundwater in storage (on the order of 1.4 million acre-feet in the depth zone of 500 to 2,500 feet); (c) the areal extent and substantial vertical depth of the Saugus; and (d) typically deep-well completions with sufficient available drawdown in the wells. The increased pumping from the Saugus would occur in dry periods, and the pumping would decline to lower values in wet and normal/average periods, to allow for recharge, such that the long-term stability in groundwater levels and storage would be maintained.

Based on work from Slade (2000) and Scalmanini (2000), the Purveyors estimate (2002 Santa Clarita Valley Water Report) that water supplies from the Saugus Formation can be withdrawn up to approximately 21,000 to 35,000 AFY in dry years, without any adverse effects, for short-term periods. It is also projected that the drilling of additional wells in the Saugus would be required to obtain these production levels for future water supplies (2002 Santa Clarita Valley Water Report).

**(c) Groundwater Flows of the Saugus Aquifer**

Groundwater movement in the Saugus Aquifer is toward the center of the valley from the highlands and then toward the western end of the Santa Clarita Valley where it discharges naturally into the Alluvial Aquifer.

**(d) Water Quality Of The Saugus Aquifer (Including Perchlorate)**

**TDS/Ammonium Perchlorate.** The primary water quality concerns in waters from the Saugus Aquifer are TDS and perchlorate detection.

**TDS.** The total dissolved solids (TDS) concentration of Saugus Formation groundwater typically ranges from 500 to 900 mg/l. The California Secondary Maximum Contaminant Level (SMCL) is expressed as a range with the midpoint or (upper) level for TDS being 1000 mg/l. No fixed consumer acceptance contaminant level has been established for TDS.

On behalf of Valencia Water Company, Richard C. Slade & Associates re-examined all available TDS data from Saugus Formation water wells in the Santa Clarita River Valley, as part of a May 2000 presentation to the California Public Utilities Commission (PUC). The PUC conducted a full evidentiary hearing on this and other issues relating to the Water Management Plan prepared by the Valencia Water Company. The original laboratory data were used to recalculate TDS using a more standard, additive method described in a United States Geological Survey report by Hem (1992). These data were then compared to historic pumping and water level records to look for any discernible trends in TDS concentrations over time, and to examine if these trends were related to changes in groundwater production.

The results of that evaluation revealed that although there has been a slight increase in TDS levels in most Saugus Formation wells in the past 40 years, this increase could not be correlated with increased groundwater production. In fact, there is some evidence that TDS concentrations actually dropped during the period of greatest Saugus Formation groundwater production.

**Ammonium Perchlorate.** As stated above, perchlorate is used in the manufacture of solid rocket propellants, missiles and fireworks. Sources of drinking water have been contaminated by perchlorate in areas in which such manufacturing has occurred. The primary human health concern related to perchlorate is that it can interfere with the thyroid gland's ability to utilize iodine to produce thyroid hormones, which are required for normal body metabolism, as well as growth and development. Perchlorate in very high doses has been used in medicine in the treatment of Graves' disease, a condition in which excessive amounts of thyroid hormone are produced.

Because perchlorate historically has not been considered a common drinking water contaminant, there are currently no federal or state drinking water standards regulating perchlorate. However, in September 2002, Senate Bill (SB) 1822 was passed. The law required the State Office of Environmental Health Hazard Assessment to perform a perchlorate risk assessment and adopt a perchlorate public health goal by January 1, 2003. SB 1822 also required the State Department of Health Services (DHS) to adopt a primary drinking water standard for perchlorate by January 1, 2004. However, the adoption of a public health goal has been delayed until later in 2004 so further research can be completed by the National Academy of Sciences.





DHS previously established an initial provisional "action level" for water utilities in the event that perchlorate is detected in an amount exceeding 18 parts per billion (ppb) or micrograms per liter (µg/l). Data from DHS showed that perchlorate concentrations lower than 18 ppb were not considered to pose a health concern for the public. In January 2002, based on draft health risk evaluations released by the U.S Environmental Protection Agency (EPA), DHS reduced the perchlorate action level to 4 ppb.

In January 1999, DHS adopted a regulation identifying perchlorate as an unregulated chemical for which monitoring is required.[16]

The alleged source of perchlorate detected in the Saugus Aquifer is a facility in the Santa Clarita Valley known as the former Whittaker-Bermite facility.[17] Perchlorate has been detected in four wells in the eastern part of the Saugus Aquifer, near the former Whittaker-Bermite facility. It has been suggested by a local environmental group that the detection of perchlorate in the Saugus Aquifer dramatically limits or precludes its usefulness as a local water supply source and that reports prepared by the water purveyors "overestimate" groundwater supplies by not properly accounting for perchlorate detected in certain wells in the Saugus Aquifer. As discussed below, the water purveyors in Santa Clarita Valley have reported the existence of perchlorate in the Saugus Aquifer for several years, and, based on the information provided below, the Saugus Aquifer remains an important and viable groundwater resource for the Santa Clarita Valley. Due to the high value of this local water resource, the purveyors have placed a high priority on replacing the impacted groundwater extraction capacity by installing wellhead treatment and the construction of new wells.

The CLWA Draft Integrated Water Resources Plan (IWRP), dated February 1998, the 1998, 1999, 2000, 2001, and 2002 Santa Clarita Valley Water Reports and the UWMP 2000 have disclosed that perchlorate was detected in certain specified wells in the Saugus Aquifer. Since 1997, groundwater samples have been collected from at least 12 municipal-supply water wells in the Saugus Aquifer for purposes of conducting laboratory testing for perchlorate. Based on laboratory test results, and additional information obtained by the water purveyors, four Saugus Formation municipal-supply wells (and one Alluvial well) located near the Whittaker-Bermite facility have been voluntarily placed on inactive status due to perchlorate detection. The location of the active and inactive wells is illustrated in **Figure 4.8-17**. The eight other Saugus wells in the area are active and available for use.

16 "Unregulated" refers to the absence of a drinking water standard, or maximum contaminant level (MCL). DHS has advised water utilities about required and recommended actions to be taken if the "action level" is exceeded, including notices to local agencies and water utility customers. For further information regarding DHS action related to perchlorate, please refer to DHS's internet website located at http://www.dhs.cahwnet.gov/, and, specifically, http://www.dhs.cahwnet.gov/ps/ddwem/chemicals/perchl/actionlevel.htm.

17 Please refer to Plate 1 in the report prepared by Richard C. Slade & Associates entitled, Hydrogeologic Conditions in the Saugus Formation, Santa Clarita Valley, California, February 2001. The report may be found in Appendix 4.8 of this report.

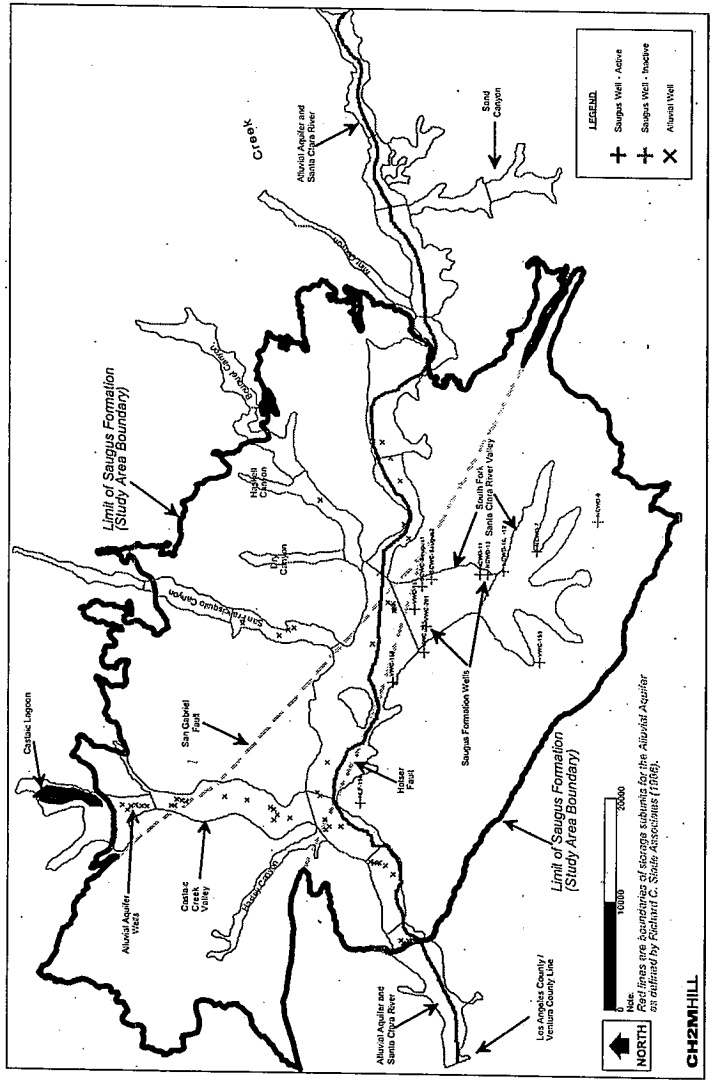



FIGURE 4.8-17

Active and Inactive Groundwater Well Locations–Santa Clarita Valley

112-16-11/03

The testing of the impacted municipal-supply wells has occurred over time. For example, testing of Newhall County Water District (NCWD) Well No. 11 showed perchlorate concentrations ranging between 9.9 and 23 ppb between May 1997 and October 2000. This well is currently on inactive operational status, and NCWD has voluntarily refrained from using the well since 1998. The testing of Valencia Water Company (VWC) Well No. 157 between 1997 and 2000 also showed perchlorate concentrations ranging from not-detected to 14 ppb. This well is also currently on inactive operational status, and VWC has voluntarily refrained from using the well since 1997. Finally, the testing of Santa Clarita Water Division of CLWA's (SCWD) Saugus-1 and Saugus-2 wells in 1997 and 1998 revealed perchlorate concentrations ranging from 16 and 42 ppb in Well Nos. 1, and 12 and 45 ppb in Well No. 2. Neither of these two wells is currently being pumped.

Results of ongoing laboratory testing of all other active Saugus Formation municipal-supply wells have shown non-detect concentrations of perchlorate. VWC Well Nos. 201, 205 and 160 were sampled and analyzed for perchlorate in June 2003, with all samples returning not-detected results. In addition, VWC sampled all of its Alluvial Aquifer municipal-supply wells in June 2003, and all samples had non-detect results. NCWD's active Saugus Formation water wells were all tested for perchlorate in October 2000 and in October 2002, with all samples returning not-detected results. Slade has reported that the Saugus Aquifer is and will continue to be a viable source of water supply for the water purveyors in the Santa Clarita Valley as long as efforts remain in place to treat impacted wells on an interim basis to contain the plume.

As to groundwater production, the voluntary closure of 4 of the 12 Saugus municipal-supply wells is due, in part, to caution related to perchlorate; however, the water purveyors have limited their use of the Saugus Aquifer for other significant reasons as well. For example, the water purveyors are pumping water from wells in the shallower Alluvial Aquifer because the water is readily available, and because it costs less to pump water from the Alluvial wells when compared to pumping from the deeper Saugus Aquifer. In addition, SWP water has been available to local purveyors since 1980, making this imported water supply more readily available than in years prior to that time. SWP water is also less expensive than pumping from the Saugus Aquifer, making SWP water a more desirable source when available. The local water purveyors also have developed an overall strategy of maintaining the Saugus Aquifer as a firming supply for drought years in the event SWP supplies are curtailed.

In addition to the water purveyors' strategy regarding groundwater production from the Saugus Aquifer, in November 2000, CLWA, NCWD, SCWD and VWC filed suit against the current and prior owners of the former Whittaker-Bermite facility. The lawsuit requests that the current and prior owners pay all necessary costs of response, removal of the perchlorate contaminant, remediation action costs and other

damages associated with the contamination. Under federal and state law, the current and prior owners of that facility have the responsibility for the clean-up activities and costs.

In 2002, CLWA and the U.S Army Corps of Engineers also entered into an agreement to assess groundwater conditions in the Saugus Aquifer within the Eastern Santa Clara Basin. Funded by a $7 million appropriation from the Federal Government, $4 million of which has been earmarked for groundwater investigations related to perchlorate contamination in the Santa Clarita Valley, with matching funds from CLWA, the purpose of the study is to sufficiently characterize the condition of the Whittaker-Bermite site and evaluate long-term and interim solutions for clean-up of the contaminated soil and groundwater. The groundwater study will be implemented pursuant to Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) and related federal regulations.[18]

Other studies regarding the nature and extent of the perchlorate in the Alluvial and Saugus Aquifers have already commenced. In addition, the local water purveyors continue routine sampling of the existing wells. CLWA's board of directors also approved a project to perform pre-design services for treatment of groundwater to contain the perchlorate plume.

The current studies are still in their initial stages; however, based on the study results to date, there is no indication that perchlorate has impacted more than the original four Saugus and one Alluvial water supply wells. Concentrations of perchlorate have been detected in Alluvial monitoring wells near the Whittaker-Bermite site boundary and in shallow groundwater under the Saugus Metrolink site, but there is no evidence that these impacts have the potential to impact Alluvial and Saugus water supply wells.

The first phase of the remedial investigation of the Whittaker-Bermite site has been completed by the U.S. Army Corps of Engineers. The scope of work of the remedial investigation includes an evaluation of the nature and extent of impacted groundwater in the study area. As part of this effort, five monitoring wells were drilled on the site at varying depths. In a May 7, 2003 memorandum entitled, Remedial Investigation Technical Memorandum No. 1, Eastern Santa Clara Subbasin Groundwater Study, Santa Clarita, California was produced. The purpose of the memorandum is to convey relevant data and information to stakeholders to facilitate decision-making for subsequent phases of the investigation. It is not intended to be a comprehensive reporting of results obtained to date. A full report will be prepared upon completion of additional field activities and full data evaluation. During the Phase I effort,

18 CERCLA is found at Title 42 USC Section 9601 at sec. Related federal regulations are also found at 40 CFR Part 300.





perchlorate levels on the Whittaker-Bermite site itself have been found to range from 3 ug/l to as high as 58,200 ug/l. This Memorandum is herein incorporated by reference.

In addition, CLWA and the other retail water purveyors in the Santa Clarita Valley plan to perform clean-up activities at the impacted well sites using treatment technologies that have been approved by the Department of Health Services. As discussed below, in the past few years, much progress has been made in developing treatment methods capable of removing perchlorate from groundwater supplies.

**Perchlorate Treatment Technology.** Effective technologies presently exist to treat perchlorate in water in order to meet drinking water standards. In a publication from the U.S. Environmental Protection Agency (EPA), Region 9 Perchlorate Update, June 1999,[19] the EPA discussed the current state of perchlorate treatment technology, and the current and planned treatment development efforts being carried out as part of U.S. EPA Superfund program studies, U.S. Air Force research, water utility-funded studies, and the Federally funded research effort underway by the East Valley Water District, California and the American Water Works Association Research Foundation (AWWARF). The EPA also summarized two of the technologies that are in use today, which are capable of removing perchlorate from groundwater supplies. Each technology is discussed below, along with a brief summary of the specific application of each method used to remove perchlorate from groundwater supplies in the San Gabriel Valley.

**Ion Exchange Method.** The first of the two perchlorate-removal technologies receiving the most attention is ion exchange, in which the perchlorate ion is replaced by chloride, a chemically similar but nontoxic ion. Ion exchange processes have been used in homes and businesses for water softening for decades. Bench- and pilot-scale studies have demonstrated that ion exchange systems can reliably reduce perchlorate concentrations in San Gabriel Valley groundwater from approximately 75 ppb to below detectable levels. The studies have also provided valuable information on resin selection and regeneration, brine production, and cost that will guide the design and operation of full-scale systems.

The ion exchange treatment method has been approved by DHS for use in the San Gabriel Basin. In February 2001, DHS approved La Puente Valley County Water District's (LPVCWD) application to amend its domestic water supply permit. After considering a detailed engineering report, and overseeing a pilot program, DHS granted LPVCWD's application to amend its domestic water supply permit, and to operate two existing domestic water supply wells in the San Gabriel Basin for purposes of treating

19 See, EPA Internet website, Perchlorate, and Region 9 Perchlorate Update, found at http://www.epa.gov/ogwdw/ccl/perchlor/perchlo.html.

perchlorate-contaminated water from the wells and providing the treated water to its customers for drinking and other domestic uses.[20]

LPVCWD's water treatment facility consists of pumping and treating perchlorate contaminated groundwater from two of its domestic-use wells. An ion separation (ISEP) unit will be used to remove the perchlorate. The ISEP process involves an ion exchange resin that is used to remove the perchlorate from the groundwater. The resulting perchlorate brine from the District's wellhead will be discharged from an existing line to either a new pipeline or the sanitary sewer system after obtaining appropriate permits from local agencies. The treatment has been demonstrated to produce final treated water to non-detect contaminate levels.

**Biological Treatment Methods.** To date, considerable effort has been directed at developing biological treatment methods for removing perchlorate from groundwater. In the biological treatment process, microbes destroy perchlorate by converting the perchlorate ion to oxygen and chloride. In most cases, nutrients must be added to sustain the microbes. Microbes have been used for decades in the treatment of drinking water supplies as part of a process known as slow sand filtration.

A six-month pilot-scale study of a biological process has been completed for the San Gabriel Basin, demonstrating the reduction of perchlorate from approximately 75 ppb to below detectable levels. The same process is being used in a recently constructed full-scale system at the Aerojet site in Northern California, where perchlorate concentrations exceed 1,000 ppb. A biological process also has been used to treat perchlorate-contaminated wastewaters resulting from the manufacture and maintenance of rocket motors, where perchlorate concentrations may exceed 500,000 ppb.

Biological treatment methods are believed to be capable of producing potable water, but additional testing must be completed to determine whether a biological process can reliably and cost-effectively produce drinking water-quality water. The necessary tests are planned for later this year, when a biological treatment system designed to produce potable water for use in the San Gabriel Valley will be in operation.

The San Gabriel Valley project involves the installation of not only the ion exchange technology to remove perchlorate, but also a second groundwater treatment system utilizing a biological process to remove perchlorate. The biological treatment train system will be constructed at LPVCWD's well site and

20 A copy of LPVCWD's Water Permit Amendment (No. 04-16-01 PA-000), dated February 15, 2001, along with the engineering report and other information are provided in Appendix 4.8 of this report.





will initially be used to demonstrate the ability to biologically reduce perchlorate concentrations using microbes. The biological treatment system will consist of a bioreactor to remove perchlorate, followed by a standard multi-media filter, followed by UV/hydrogen peroxide (oxidation) to lower contaminant concentrations to comply with DHS drinking water standards. The treated water will flow through Granular Activated Carbon (GAC) pressure vessels to "polish" the treated water to ensure that all contaminants are removed. The fully-treated water will then be disinfected.

During the demonstration, all water treated by the biological treatment system will be discharged in compliance with an NPDES permit, which will be obtained from the Regional Water Quality Control Board. After the demonstration phase, a permit will be requested from DHS to provide the full-treated water to LPVCWD's customers. Following receipt of the DHS permit, the biological treatment train system will continue to operate and provide fully-treated water to LPVCWD customers. As part of the biological treatment system, ethanol will be stored on site and used to foster microbial growth. A permit will be obtained from the local agency to store the ethanol on site.

Biological treatment methods are new to many water utilities. However, biologically-active filters have been used in drinking water treatment for decades to help remove particles and biodegradable organic matter. As stated above, the San Gabriel Valley project will rely on biological treatment for primary perchlorate removal, and is expected to include GAC as a backup process capable of limited perchlorate removal.

**Other Treatment Methods.** Other technologies have also been demonstrated as capable of removing perchlorate, but probably at higher cost. Reverse osmosis and nanofiltration were tested by researchers at the Metropolitan Water District of Southern California and shown to be effective in removing perchlorate, but they are likely to be much more expensive to operate than ion exchange processes. Liquid phase GAC also removes perchlorate, but only for a limited period of time before regeneration or replacement of the carbon is required. Frequent carbon replacement would make relying solely on GAC for perchlorate removal very expensive. Perchlorate cannot be removed from water by conventional filtration, sedimentation or air stripping technologies.

In addition to the proven treatment methods, a U.S. patent was recently granted for a new treatment device that reportedly renders perchlorate harmless. The device is a hollow-fiber membrane biofilm reactor, which, through a natural biochemical process of electron transfer, turns perchlorate into innocuous chloride. Perchlorate contaminated water is run through the biofilm reactor, which contains a bundle of thousands of hollow fiber membranes into which hydrogen gas is fed. The hydrogen gas diffuses through the membrane walls into the water as it flows past the fibers. Bacteria attach to the

surface of the membrane because they gain energy from the process of transferring electrons and act as catalysts for the transfer of electrons from hydrogen gas to the oxidized contaminant, such as perchlorate. The contaminants are reduced to harmless end products while the hydrogen gas is oxidized to water.

The advantage of the biofilm reactor method over existing methods is that it destroys the contaminant without creating brine or other waste products, which must then be disposed of. The creators of the biofilm reactor device have embarked on a pilot study of the treatment method in La Puente, California, treating groundwater that is highly contaminated with perchlorate. Results of the study have shown that the biofilm reactor can effectively treat 0.3 gallons of water per minute. The current research is supported by a grant from the U.S. Environmental Protection Agency and administered by AWWARF.

In the coming year, the results of perchlorate treatment research funded by a $2 million federal appropriation to the AWWARF will be available. AWWARF is funding studies into biological treatment methods, ion exchange, reverse osmosis, nanofiltration and other processes. The result of the AWWARF research should allow more efficient design and operation of the ion exchange and biological treatment processes, and may identify other technologies capable of cost-effectively removing perchlorate from water.

**Summary.** Due to the high value of this local water resource, the purveyors have placed a high priority on replacing the impacted groundwater extraction capacity by installing wellhead treatment and the construction of new wells. The "best" technology for removal of perchlorate will probably vary from site to site. At this time, however, ion exchange and biological treatment systems have been approved for construction and operation in the San Gabriel Valley. The San Gabriel Valley project will continue to provide cost and performance data over the years that will be available to other water utilities for other sites. The results from recent and ongoing studies will also be of use to water utilities in need of reliable, easy-to-operate treatment methods that can reduce perchlorate concentrations to low or non-detectable levels.

**Other Water Contaminants.** Water quality regulations are constantly changing as contaminants that are not typically found in drinking water are being analyzed by DHS and U.S. EPA. In addition, existing water quality standards are becoming more stringent in terms of allowable levels in drinking water.

**Hexavalent Chromium.** Over the past year, hexavalent chromium (chromium 6) has become an important new water quality concern in Southern California. In a letter dated March 27, 2001, DHS asked the California Environmental Protection Agency to establish a specific public health goal (PHG) for chromium 6. The PHG would formally identify a level of chromium 6 in drinking water that does not





pose a significant human health risk. DHS has adopted regulations adding chromium 6 to the list of unregulated chemicals requiring monitoring, effective January 3, 2001. The regulations require drinking water systems to monitor for unregulated chemicals for which drinking water standards have not been established. The objective of the regulations is to collect data throughout the state to determine the occurrence of these chemicals to help DHS make regulatory decisions that will adequately protect public health.

DHS currently regulates chromium in drinking water as total chromium. DHS's drinking water standard for total chromium is 50 parts per billion (ppb). Total chromium is comprised of chromium 3 and chromium 6. Both are naturally occurring and are found in groundwater. Chromium 3 is an important dietary supplement necessary for public health. While chromium 6 is a known occupational carcinogen through inhalation, scientists differ over the potential health effects posed when consumed in water. Due to the level of public concern about chromium 6, the DHS regulations were adopted on an emergency basis to expedite monitoring for this chemical. All drinking water systems with sources determined by DHS to be vulnerable to chromium 6 must monitor to enable DHS to determine both its occurrence and the proportion of chromium 6 in the "total chromium" level.

The retail water purveyors in the Santa Clarita Valley have implemented a monitoring schedule in compliance with these regulations. Preliminary scanning samples taken throughout the Santa Clarita Valley have shown trace levels (<1 ppb) of chromium 6. These levels are likely attributed to naturally occurring chromium in the rocks and soil. For further information, please refer to the following DHS website, http://www.dhs.ca.gov/ps/ddwem/chemicals/Chromium6/Cr+6index.htm.

**MTBE.** Additional water quality regulations have been promulgated and/or revised over the past several years. For example, MTBE (methyl-tertiary-butyl ether) has been a concern for the past few years, and on May 17, 2000, DHS adopted a primary maximum contaminant level (MCL) for MTBE of 0.013 mg/L. CLWA and the local water purveyors have been testing for MTBE since 1997, and, to date, have not detected it in any of the production wells or in the treated SWP water supplies.

**(3) Summary of Local Groundwater Supplies**

In summary, **Table 4.8-3**, shows the existing and projected groundwater supplies from the Alluvial and Saugus Aquifers. The groundwater projections are from the UWMP and the updated analysis by Slade (UWMP 2000, Appendix 4.8).

**Table 4.8-3**
**Existing and Planned Groundwater Supplies[1]**
**(acre-feet per year)**

| Source | Average/Normal Year | Dry-Year |
|---|---|---|
| Alluvial Basin | 35,000 | 35,000 |
| Saugus Formation | 11,000 | 13,000 |
| Saugus Formation (new wells)[2] | | 20,000 |
| Total Supply | 46,000 | 68,000 |

*Source: SB 610 Water Supply Assessment of the Riverpark Project, Santa Clarita Water Division, 2003.*
[1] *Studies by Richard Slade & Associates in October 2000, and the Santa Clarita Valley Water Report 2002, April 2003.*
[2] *Planned program for future implementation. Prior to implementing increases in production from groundwater supplies, CLWA will analyze the feasibility, cost and potential water quality and environmental effects of such a program. However, preliminary analyses and recent studies (Slade 2000) have concluded that additional pumping can be carried out.*

## c. Reclaimed Water Supplies

Water reclamation (or recycling) is defined as the treatment and disinfection of municipal wastewater to provide a water supply suitable for non-potable reuse (e.g., landscape irrigation). Under specified conditions, the state now requires the use of reclaimed water when available. (See SB 2095 [Johnston] and Government Code Section 65602 relating to water recycling.) Section 65602 states in part:

> *"(a) The waters of the state are of limited supply and are subject to ever-increasing demands.*
>
> *(b) The continuation of California's economic prosperity is dependent on adequate supplies of water being available for future uses.*
>
> *(c) It is the policy of the state to promote the efficient use of water through the development of water recycling facilities.*
>
> *(d) Landscape design, installation, and maintenance can and should be water efficient.*
>
> *(e) The use of potable domestic water for landscaped areas is considered a waste or unreasonable use of water within the meaning of Section 2 of Article X of the California Constitution if recycled water is available that meets conditions described in Section 13550 of the Water Code."*

Section 65605(b) also requires that a local agency adopt a recycled (or reclaimed) water ordinance that will:

> *"[S]tate that it is the policy of the local agency that recycled water determined to be available pursuant to Section 13550 of the Water Code shall be used for non-potable uses within the designated recycled water use area set forth by the local agency when the local agency determines that there is not an alternative higher or better use for the recycled water, its use is economically justified, and its use is financially and technically feasible for projects under consideration by the local agency."*





Reclaimed water is available for use in the Santa Clarita Valley from two existing WRPs operated by the County Sanitation Districts of Los Angeles County, the Saugus WRP, located in District 26 and the Valencia WRP, in District 32.

CLWA is currently in the process of updating its Reclaimed Water System Master Plan (Master Plan). The purpose of the Master Plan is to evaluate and plan for the use of reclaimed water as a reliable water source to meet a portion of the non-potable water demand in the Santa Clarita Valley. The prior version of the Master Plan (Kennedy Jenks Consultants, 1993) outlined a multi-phase program to deliver reclaimed water to the valley totaling 10,000 acre-feet. CLWA's reclaimed water supply is approximately 1,700 AFY. Projections by CLWA show a total reclaimed water supply of 17,000 acre-feet by the year 2020. This amount is in addition to the reclaimed water originating at the proposed Newhall Ranch WRP.[21]

**Reclaimed Water Demand.** The Master Plan identified potential reclaimed water users with existing and future demands totaling 10,361 AFY. Of the total demand, 1,215 AFY of demand is outside the CLWA service area.

Since reclaimed water is used for non-potable purposes such as landscape irrigation, demand for reclaimed water follows a highly seasonal pattern. Reclaimed water demand is generally low during wet winter months and increases dramatically during hot, dry summer months to meet greater irrigation requirements. For the annual demand of 10,361 AFY identified in the Master Plan, the total peak monthly demand is 1,922 acre-feet and the total peak daily demand is 20.5 mgd (1 acre-foot of water is equivalent to 325,850 gallons).

In addition to the reclaimed water demand identified in the Master Plan, when the proposed Newhall Ranch Specific Plan is constructed, the non-potable water demand in the CLWA service area could increase by 9,035 AFY (Newhall Ranch non-potable demand). The peak monthly non-potable demand for Newhall Ranch has been estimated to be 1,275 acre-feet (approximately 13.8 mgd). Assuming construction of the Newhall Ranch Specific Plan, the total non-potable water demand within the CLWA's service area is expected to reach approximately 19,396 AFY. This demand will be highly seasonal, with peak demands during summer months when the weather is hot and dry and irrigation needs are greatest.

21 See, CLWA's SB 610 Water Supply Assessment for the Riverpark Project, which is attached to this analysis as Appendix 4.8. See also, CLWA's draft Reclaimed Water System Master Plan (Kennedy Jenks Consultants, 1993), which is incorporated by reference and available for public review at the City of Santa Clarita Planning Department.

Table 4.8-4, below, summarizes the reclaimed water demands.

**Table 4.8-4**
**Reclaimed Water Demand**

| Item | Annual Demand (acre-feet per year) | Peak Monthly Demand (acre-feet) | Peak Demand (acre-feet) | Daily mgd |
|---|---|---|---|---|
| Within CLWA Service Area[a] | 9,146 | 1,690 | 55.6 | 18.00 |
| Outside CLWA Service Area[a] | 1,215 | 233 | 7.5 | 2.45 |
| Newhall Ranch[b] | 9,035 | 1,275 | 42.5 | 13.81 |
| Total | 19,396 | 3,198 | 105.6 | 34.26 |

[a] *From CLWA Reclaimed Water Master Plan, September 1993.*
[b] *From CLWA Integrated Water Resources Plan, Water Demand and Supply Evaluation, February 1998; Technical Memorandum, Update to: Addendum to Water Resources and Wastewater Management for the Newhall Ranch Project, January 18, 1999, CH2MHILL.*

**Reclaimed Water Supplies.** The two existing WRPs in the Santa Clarita Valley that can potentially supply reclaimed water to meet the identified non-potable water demands in the CLWA service area are the Valencia WRP and the Saugus WRP. A third plant has been proposed as part of the Newhall Ranch Specific Plan.

Due to site space constraints, the Saugus WRP, completed in 1962, will not be expanded beyond its current permitted capacity of 6.5 mgd. In 2002, the Saugus WRP had an average monthly effluent flow of 5.60 mgd (6,294 AFY), which is approximately 86 percent of its permitted capacity. Effluent from the Saugus WRP contains about 723 milligrams per liter TDS (total dissolved solids) and is discharged to the Santa Clara River west of Bouquet Canyon Road.

The Valencia WRP, completed in 1967, has a current permitted capacity of 12.6 mgd. The ultimate planned capacity for the Valencia WRP is 27.6 mgd. In 2002, the average monthly effluent flow for the Valencia WRP was 12.11 mgd, which is approximately 96 percent of its current permitted capacity. Effluent from the Valencia WRP contains approximately 753 milligrams per liter TDS (total dissolved solids) and is discharged to the Santa Clara River west of The Old Road.

The Newhall Ranch Specific Plan proposes a 6.9 mgd WRP on the Newhall Ranch site to exclusively serve the Specific Plan. The proposed Newhall Ranch WRP would be located near the western edge of the Specific Plan site along the south side of SR-126. Effluent from the proposed Newhall Ranch WRP would be used to partially meet non-potable water demands within the Specific Plan site. According to the Newhall Ranch Final EIR, the proposed WRP is projected to produce on average approximately 5,630





AFY. Of this amount, 5,344 AFY would be used for irrigation, with the remaining 286 AFY discharged to the Santa Clara River during winter months when demands are low. This supply is projected to meet approximately 59 percent of the 9,035 AFY of potential non-potable water demands for the Specific Plan. The remainder of the non-potable demand is expected to be met by reclaimed water from CLWA, consistent with its updated Reclaimed Water System Master Plan.

Table 4.8-5 summarizes CLWA's reclaimed water supplies:

**Table 4.8-5**
**Reclaimed Water Supplies**

| | Current Capacity (mgd) | Ultimate Capacity (mgd) | Flow (1999) mgd | Flow (1999) acre-feet | TDS (mg/1) |
|---|---|---|---|---|---|
| Saugus WRP | 6.5 | 6.5 | 5.60 | 6,271 | 723 |
| Valencia WRP | 12.6 | 27.6 | 12.11 | 12,856 | 753 |
| Total | 19.1 | 34.1 | 16.06 | 19,127 | -- |

*Source: County Sanitation Districts of Los Angeles County, Letter Dated January 13, 2003.*

## d. Imported SWP Water Supplies

### (1) SWP Overview

In 1951, the California Legislature authorized construction of a large state water storage and delivery system.[22] Eight years later, in 1959, the Legislature authorized the submission for voter approval of a $1.75 billion general obligation bond issue to build the State Water Project (SWP) system. The voters approved the measure, which enabled DWR to commence construction of the SWP.[23]

The DWR operates and manages the SWP facilities.[24] The SWP is the largest state-built, multi-purpose water project in the country. The SWP was designed and built to deliver water, control floods, generate power, provide recreational opportunities and enhance fish and wildlife habitats. SWP water supplies are used for both urban and agricultural uses throughout California. The SWP facilities consist of a complex system of dams, reservoirs, power plants, pumping plants, canals and aqueducts to deliver water.[25]

22 DWR, Bulletin No. 132-95 (Nov. 1996) p. xxiii; DWR Bulletin No. 132-98 (Nov. 1999) p. xxvii-xxxv.
23 Wat. Code §12930 et seq.; DWR, Bulletin No. 132-93 (Sept. 1994) p. 15.
24 DWR, Bulletin No. 132-93, (Sept. 1994) p. 15.
25 DWR, Bulletin No. 132-98 (Nov. 1999) p. xxvii.

At the inception of the SWP, DWR entered into individual water supply contracts with agricultural and urban water suppliers (SWP contractors) throughout California. The contracts were the method used to fund construction and operation of the SWP facilities for the delivery of water to the SWP contractors. Each such contract sets forth a maximum annual allocation of SWP water, which is stated in Table A to the contract (Table A Amount, or allocation).

There are currently 29 SWP contractors with water supply contracts with DWR. A SWP contractor may annually request that DWR deliver water in the following year in any amount up to the SWP contractor's Table A Amount. The SWP contracts provide that in a year when DWR is unable to deliver the full amount of contractor requests, deliveries to contractors will be reduced so that total deliveries equal total available supply for that year. Some SWP contractors, including CLWA, historically have never requested delivery of their full annual amount because lower growth, other water supplies and water conservation efforts have held their demand below projections. Other SWP contractors historically have ordered their full Table A Amount nearly every year.

Existing long-term SWP water supply contracts called for the annual delivery of 4,103,651 acre-feet of Table A water by 1997 through SWP facilities, gradually increasing to a maximum of 4,172,686 acre-feet by 2020. Actual demand, however, has also not developed as projected, owing to circumstances, which have changed since the long-term contracts were signed in the 1960s. The changes include slower population growth, changes in local land use, local water conservation programs and conjunctive-use programs. The most SWP Table A water delivered to date (2003) in any year was about 3.5 million acre-feet in 2000.[26] The demands for SWP water are expected to increase as the population of California continues to increase.[27]

(2) Monterey Agreement

By 1994, disputes arose among the many agricultural and urban SWP contractors and DWR regarding the availability and distribution of water through SWP facilities. To avoid potential litigation, DWR and agricultural and urban SWP contractors met in Monterey, California to attempt to resolve the ongoing disputes. After negotiations, DWR and the agricultural and urban SWP contractors agreed to a statement of principles, which became known as the "Monterey Agreement."

The Monterey Agreement, signed by DWR and many of the agricultural and urban SWP contractors in 1994, established principles to be incorporated in contract amendments (the Monterrey Amendments) to be offered to the SWP contractors. To date, all but two SWP contractors (Plumas County Flood Control

26 See, The State Water Project Delivery Reliability Report, 2003, Final, Department of Water Resources, Bay Delta Office.

27 See, DWR, Bulletin 132-98 (Nov. 1999), p. xxvii.





and Water Conservation District and Empire West Side Irrigation District) have accepted the amendments. The amendments have three primary objectives: (i) to increase the reliability of all SWP contractors' water supplies; (ii) to stabilize the rate structure in order to improve the financial viability of the SWP; and (iii) to increase water management flexibility for all SWP contractors.

The Monterey Agreement provided a number of water management tools that have allowed local agencies to maximize their use of available supplies, thus meeting increased demand without construction of new SWP facilities. Most of these tools are environmentally beneficial or neutral. They include:

(a) **Water Transfers.** SWP contractors can transfer unneeded Table A water to other contractors on a permanent basis. This provides financial relief from SWP charges for the seller and additional water supplies for the buyer.

(b) **Turnback Pool.** SWP contractors with unneeded supplies on a short-term basis can turn their water back into a pool for purchase by other contractors.

(c) **Storage Outside Service Area.** SWP contractors are permitted to store water outside their service area (for example, in a groundwater banking project) for later use within their service areas.

(d) **Terminal Reservoirs.** SWP contractors are permitted to utilize flexible storage in Castaic Lake and Lake Perris to enhance their water supply reliability.

(e) **SWP Allocation.** Allocation of available SWP supply is made based on the proportion of each contractors' maximum contractual Table A water, rather than historical use with agricultural SWP contractors being cut first as in the past. This provides additional reliability to agricultural contractors earlier in the year, which improves their planning capability.

(f) **Interruptible Water.** Interruptible water (available surplus water) is distributed on an equal basis among SWP contractors rather than to agricultural SWP contractors first.

(g) **Flexibility.** Additional flexibility is granted to SWP contractors wishing to increase or decrease the Table A Amounts in their contracts.

(h) **Banking.** The Kern Water Bank was transferred to SWP agricultural users for development and use. This transfer has provided agricultural users as well as other local agencies with additional flexibility and water supply reliability.

(i) **Non-Project Water.** Use of project facilities for conveyance of non-project water is permitted to assist SWP contractors, which are able to locate additional sources of water.

As stated above, the Monterey Agreement has facilitated water transfers among SWP contractors. These water transfer provisions have resulted in 130,000 acre-feet of agricultural SWP contractors' Table A Amount being available for sale to urban SWP contractors. Agreements already have been executed among contractors to purchase the additional Table A water from the agricultural SWP contractors. Agreements for the additional Table A Amount of SWP water are effective upon execution (DWR Bulletin No. 132-96, August 1997, Ch. 1, p. 5), and, therefore, are considered permanent water reallocations of SWP Table A water. These permanent transfers of SWP Table A Amounts have allowed urban SWP contractors to obtain additional SWP Table A Amounts, thereby increasing their overall deliveries, even

in times of drought. The permanent transfers of SWP Table A Amounts have also allowed SWP urban contractors to increase the reliability of their deliveries by having more Table A Amounts available overall.

The DWR now has approximately eight years of experience in implementing the Monterey Agreement and the associated water management tools identified above. The SWP contractors have come to rely on the Monterey Agreement water management tools and other provisions in their planning activities. Some of the results to date include:

(a) Up to 200,000 acre-feet transferred annually in the Turnback pool program;

(b) Nearly 114,000 acre-feet transferred in permanent Table A water transfers;

(c) Nearly 1,000,000 acre-feet stored outside SWP contractors' service areas;

(d) Utilization of terminal reservoirs' flexible storage; and

(e) Delivery of up to 200,000 acre-feet annually in Interruptible water (available surplus water).

**(3) Monterey Agreement Environmental Review and Litigation**

The Monterey Agreement gave rise to potentially significant environmental effects requiring analysis under the California Environmental Quality Act. Therefore, a Program EIR was prepared to address the potentially significant environmental effects of implementing the Monterey Agreement. The Final Program EIR was certified in October 1995. The adequacy of the Final EIR was challenged in litigation arising under the California Environmental Quality Act. The Sacramento Superior Court upheld the adequacy of the EIR. Before and after the trial court's decision, DWR and the agricultural and urban SWP contractors who had executed the Monterey Agreement began implementing various amendment provisions, including the completion of permanent transfers of Table A Amounts among agricultural and urban SWP contractors. The trial court's decision was subsequently appealed. On appeal, the petitioners sought a writ to prevent further implementation of the Monterey Agreement during the appeal. However, the appellate court denied the requested writ (DWR Bulletin 132-98, November 1999, Ch. 6, p. 2).

The appellate court reversed the trial court's decision. The appellate court held that the Program EIR for the Monterey Agreement was improperly prepared by the Central Coast Water Agency, as "Lead Agency" under CEQA, rather than by DWR, which should have been the "Lead Agency." The appellate court also found that the EIR did not sufficiently discuss implementation of a "no project" alternative.





The court then concluded that a new EIR must be prepared and certified. Finally, the court held that the trial court improperly dismissed the plaintiffs' challenge to DWR's transfer of title to the Kern Water Bank from DWR to Kern County Water Agency.

The appellate court then remanded the case to the trial court and directed that the trial court issue a writ of mandate vacating certification of the EIR and retaining jurisdiction until DWR certifies an EIR in accordance with CEQA. The appellate court further directed that the trial court consider whether the Monterey Agreement may continue to be implemented while the new EIR is being prepared. (*Planning & Conservation League v. Department of Water Resources* (2000) 83 Cal.App.4th 892.)

The appellate court decision invalidated certification of the EIR, but did not set aside, invalidate or otherwise vacate the Monterey Agreement. In addition, no court orders have been issued to "stay" further implementation of the Monterey Agreement.

In October 2000, DWR filed a petition asking the California Supreme Court to review the appellate court decision. The California Supreme Court denied the petition for review and the matter was remanded to the trial court for further proceedings, consistent with the appellate court's decision. The trial court has not issued a final ruling in the action.

In March 2001, the parties to the Monterey Agreement litigation commenced confidential mediation discussions in San Francisco. In a "Joint Statement on the Monterey Amendments Litigation," dated July 18, 2002, the parties to the litigation stated that they "have reached a joint agreement on the principles for settling the lawsuit[.]" The parties also stated that DWR had commenced preparing a new EIR for the Monterey Agreement. In May 2003, the Department of Water Resources, Central Coast Water Authority, Kern Water Bank Authority and certain State Water Project Contractors entered into a Settlement Agreement (Settlement) with the Planning and Conservation League, Plumas County Flood Control and Water Conservation District, and Citizens Planning Association of Santa Barbara County, Inc. Pursuant to the Settlement, the Department agreed to public negotiation of certain amendments to the long term water supply contracts, including contract amendments to transfer Table A Amounts between existing SWP contractors. The settlement also contains an "Acknowledgment and Agreement Regarding Kern-Castaic Transfer" (i.e., the 41,000 acre-foot CLWA/WRMWSD water transfer described in section (4) below). The settlement states: "...nothing in this Settlement Agreement is intended to predispose the remedies or other actions that may occur in [the] litigation [on the 41,000 acre-foot transfer]." Consequently, the decisions reached in that litigation stand. The full text of the Settlement and further information regarding the Monterey Agreement and Monterey Amendment, including future opportunities for public involvement are available on the worldwide web at

http://www.montereyamendments.water.ca.gov/. A copy of the settlement is also included in Appendix 4.8 to this report.

(4) Santa Clarita Valley SWP Supplies

**CLWA SWP Table A Amount.** Imported water from the SWP has been a supplemental source of supply to the Santa Clarita Valley since 1980. The SWP is contracted (and designed) to deliver approximately 4.2 million acre-feet of water per year to 29 contracting agencies. However, because the SWP has not been completed, it cannot yet deliver the entire 4.2 million acre-feet. CLWA is a contracting agency with a current maximum annual SWP Table A Amount of 95,200 AFY, or about 2.3 percent of the total (The CLWA/WRMWSD water transfer of 41,000 AFY has been completed, CLWA has paid approximately $47 million for the additional Table A Amount, the monies have been delivered, the sales price has been financed through CLWA by tax-exempt bonds, and DWR has increased CLWA's SWP maximum Table A Amount to 95,200 AFY because it was a permanent transfer/reallocation of SWP Table A entitlement between SWP contractors).

Prior to completion of the CLWA/WRMWSD water transfer, the proposed transfer was the subject of environmental review by the water agencies. The agencies selling the 41,000 acre-feet of SWP Table A Amount to CLWA assessed the environmental consequences of the proposed transfer within their service area in a Final EIR, dated June 1998. This EIR was certified in 1998 and has never been the subject of judicial review. As a result, the EIR is conclusively presumed to be valid. (Pub. Res. Code §21167.2)

CLWA also prepared a supplemental Final EIR, which assessed the environmental effects of CLWA's acquisition of the 41,000 acre-feet within its service area. The Board of Directors of CLWA certified the Supplemental Final EIR in March 1999. Thereafter, in April 1999, a lawsuit was brought challenging the adequacy of the EIR under CEQA (*Friends of the Santa Clara River, et al. v. Castaic Lake Water Agency, et al.*, Case No. BS 056954). The trial court ruled in favor of CLWA and upheld the adequacy of the EIR under CEQA.

In October 2000, the plaintiffs filed an appeal. The appellate court reversed the trial court's judgment and ordered CLWA's EIR decertified. However, the appellate court did not order CLWA to void its approval of the water transfer. Instead, the appellate court remanded the matter to the trial court for further proceedings. After a hearing on September 24, 2002, the trial court concluded that CLWA could utilize the 41,000 AFY to which it is entitled.





**Status of CLWA's Acquisition Under the Monterey Agreement.** The CLWA/WRMWSD transfer of SWP Table A Amount was the type of water transfer that fell within the provisions of the Monterey Agreement. As stated above, under the Monterey Agreement, certain SWP agricultural contractors agreed that 130,000 acre-feet of their Table A Amount could be transferred to urban contractors. The CLWA 41,000 acre-feet acquisition was a part of the 130,000 acre-feet of SWP Table A Amount, which has been transferred under the Monterey Agreement.

In effect, the Monterey Agreement provided a blanket pre-approval for those transfers by the participating SWP contractors, thus facilitating transfers of Table A Amounts from agricultural to urban SWP contractors. As stated above, the environmental documentation for the Monterey Agreement has been decertified. However, the pending legal proceedings have not invalidated the Monterey Agreement or enjoined either the Monterey Agreement or further implementation of the Monterey Agreement.

Even in the absence of the Monterey Agreement, CLWA's permanent acquisition of an additional 41,000 acre-feet of SWP Table A Amount could occur under existing SWP water supply contract provisions, subject to appropriate environmental review.

Nothing in the existing SWP water supply contracts, or applicable law, prohibit such water transfers with or without the Monterey Agreement. The Monterey Agreement simply provides a specific vehicle for accomplishing transfers of SWP Table A Amounts from agricultural to urban SWP contractors; the amendments under the Monterey Agreement are not the exclusive means by which that Amount may be transferred. In support of that fact, in 1981 (almost 15 years before the Monterey Agreement), the entire SWP Table A Amount of the Hacienda Water District was permanently transferred to the Tulare Lake Basin Water Storage District, pursuant to an agreement approved by DWR.

The acquisition of the 41,000 acre-feet could proceed as a water transfer under existing law. See, e.g., Water Code §§382, 383 (authority for transferring surplus water) and Water Code §1745, et seq. (authority for transferring non-surplus water). The Kern County Water Agency has reaffirmed its willingness to allow transfers of up to 130,000 acre-feet of SWP Table A Amounts under pre-Monterey Agreement conditions even if the Monterey Agreement is ultimately invalidated.

If it were not for existing SWP water supply contract provisions which allow such transfers (without the need for the Monterey Agreement), and existing law which enables CLWA to enter into contracts outside the context of the Monterey Agreement, an adverse final judgment invalidating the Monterey Agreement could affect CLWA's completed acquisition of the 41,000 acre-feet, which could in turn impair CLWA's supply of SWP water through its contracts with DWR and other SWP contractors. However, CLWA

believes that an adverse outcome in the Monterey Agreement litigation is not likely to adversely affect CLWA's water supplies over the long term because CLWA believes that such a result is unlikely to "unwind" executed and completed agreements with respect to the permanent transfer of SWP Water Amounts.

(5) CLWA SWP Deliveries

With limited exception, as shown below, DWR's allocation to CLWA has been 100 percent of CLWA's actual request for SWP water supplies. Based on annual water supply information provided by DWR, there have been only two years on record since 1980 (1991 and 1992) when DWR's delivery to CLWA was not 100 percent of CLWA's requested need. Despite the reduced DWR allocation in those two years, the amount of SWP water delivered to CLWA was sufficient to meet all local water supply needs in the Santa Clarita Valley. Table 4.8-6, below, summarizes the DWR's annual SWP supply to CLWA from 1990 to 2003.

Table 4.8-6 includes several important features regarding CLWA's annual water supply since 1990. The features of this table, are discussed below.

The "Maximum Table A Amount" column represents CLWA's possible maximum total annual allocation of SWP Table A water. From 1990 until 1999, CLWA's full (maximum) annual SWP Table A Amount was 54,200 AFY. The full annual SWP Table A Amount of 95,200 AFY, shown in the "Maximum Table A Amount" column in the years 2000, 2001, 2002, and 2003 reflects the permanent acquisition of an additional 41,000 AFY of SWP Table A Amount in 1999 from the Kern County Water Agency.

The "DWR Allocation" column represents the amount (%) of the Table A water allocated to CLWA by DWR. Note that it has often been the case (e.g., 1995–2003) that CLWA received from DWR an allotment of Table A water far in excess of its actual need. Consequently, CLWA turned back (returned) significant amounts of water into the turnback pool.





**Table 4.8-6**
**Castaic Lake Water Agency**
**Annual SWP Water Supply Information**
**from Department of Water Resources**

| Year | CLWA Maximum Table A Amount (AF) [1] | DWR Allocation (%) [2] | Table A Amount Allocated (AF) | Imported Water Delivered/ Need (AF) | Percent of Table A Amount Delivered (%) |
|---|---|---|---|---|---|
| 1990 | 54,200 | 100% | 54,200 | 21,613 | 40% |
| 1991 | 54,200 | 30% | 16,260 | 7,968 | 49% |
| 1992 | 54,200 | 45% | 24,390 | 13,911 | 57% |
| 1993 | 54,200 | 100% | 54,200 | 13,393 | 25% |
| 1994 | 54,200 | 50% | 27,100 | 14,389 | 53% |
| 1995 | 54,200 | 100% | 54,200 | 16,996 | 31% |
| 1996 | 54,200 | 100% | 54,200 | 18,093 | 33% |
| 1997 | 54,200 | 100% | 54,200 | 22,148 | 41% |
| 1998 | 54,200 | 100% | 54,200 | 20,254 | 37% |
| 1999 | 54,200 | 100% | 54,200 | 27,282 | 50% |
| 2000 | 95,200 | 90% | 85680 | 32,579 | 38% |
| 2001 | 95,200 | 39% | 37,128 | 35,369 | 95% |
| 2002 | 95,200 | 70% | 66,640 | 41,768 [4] | 62% |
| 2003(est) | 95,200 | 90% | 85,680 | 42,000 [4] | 49% |

[1] ***CLWA Maximum Table A Amount:*** *Represents CLWA's contract rights to SWP water since 1990. There are 29 contracting agencies with a maximum SWP Table A Amount totaling 4,172,786 acre-feet. In 1992, CLWA acquired the water supply of the Devil's Den Water District (i.e., its 12,700 AFY Table A Amount). By Year 2000, CLWA had acquired 41,000 AFY of Table A amount from the Kern County Water Agency and the Wheeler Ridge-Maricopa Water Storage District.*

[2] ***DWR Allocation:*** *Represents the Table A Amount allocated to CLWA by DWR. Note that it has often been the case (e.g., 1995-2003) that CLWA received from DWR an allotment of their Table A Amount far in excess of its actual need. Consequently, CLWA turned back (returned) significant amounts of water into the turn-back pool.*

[3] *Actual imported water delivered by CLWA in 1991 was 3,846 AF and 11,890 AF in 1992. The difference between these deliveries and the Imported Water Delivered/Need column is the amount of groundwater pumped into CLWA's system during 1991 and 1992.*

[4] *CLWA also delivered to the Semitropic Water Storage District a total of 24,000 AF in 2002 and 35,000 AF in 2003 to be stored for CLWA's future use.*

***Other observations:*** *In 1994, CLWA deliveries were disrupted by the Northridge Earthquake. The Table does not account for Devil's Den deliveries, carryover provisions of the SWP contract, Article 21 water deliveries, turn-back water pool purchases, flexible storage account balance and deliveries, transfers to Westlands Water, Flood Flow deliveries, groundwater pumped during the 1991 drought into CLWA's system, etc.*

The "Table A Amount Allocated" column is the amount of CLWA's Table A Amount available for delivery to CLWA in a given year by DWR. Many factors can affect the amount of water delivered by DWR, including environment conditions and weather. The "Imported Water Delivered/Need" column is the actual amount of SWP water required by CLWA to meet local water demand. Since 1990, this amount is typically far less than the amounts available to CLWA. These deliveries include not only the Table A water, but also local groundwater, "Carry-Over," "Interruptible" and "Local Flood Flow Water" supplied by DWR over the years. Had CLWA participated in any "Drought Water Bank" programs, DWR deliveries under such programs would have been reflected in this column as well; however, CLWA has not needed to participate in any of the statewide drought programs due to available local supplies and voluntary conservation programs.

DWR's annual Turnback Pool program has been in place since execution of the Monterey Amendments. The program is an internal SWP mechanism that provides for pooling potentially unused SWP supplies early in the year for purchase by other SWP contractors at a set price. The program is intended as an incentive to return unneeded water early in the year for reallocation among SWP contractors on willing-buyer/seller basis. See, Critical Water Shortage Contingency Plan, Governor's Advisory Drought Planning Panel, December 29, 2000, p. 3-11.

Through this program, any SWP water that CLWA deems is not needed in a given year is returned to DWR. This unused water is then made available to the SWP and other SWP contractors. CLWA participated as a "seller" in this program from 1996 through 2000, with over 127,000 acre-feet in sales of unused water. Several other SWP contractors have also returned unused SWP water to DWR, with a 5-year total return of over 1 million acre-feet. Under this program, CLWA could participate as a "buyer," rather than a "seller," in the event additional SWP supplies were needed for storage, water banking projects or other conjunctive use programs.

DWR also conducts a "Dry Year Program" to allow water users such as CLWA to obtain supplemental supplies during dry years. The program provides "options" purchases as well as direct purchases of water. Under the Program, DWR attempts to negotiate water purchases from farmers in the Sacramento Valley. Participating farmers will receive funds that will enable them to fallow, pump groundwater, or shift to an alternative (lower water use) crop. The water sold by the farmers will then be placed into a pool of water that will be allocated among water users who wish to participate in the Dry Year Program. This pool will be allocated based on the total number of participants and the relative amounts of water they request. The program is open to all water users in California. In 2001, CLWA submitted an initial request to purchase up to 12,000 acre-feet through the program. While CLWA did not participate in the Dry Year Program for 2001 and 2002 because CLWA ultimately received a large enough SWP allocation from DWR, the program was available to the agency showing the considerable flexibility of DWR, SWP contractors, and the retail purveyors to adapt to changing water supply forecasts and reliability levels. Documents demonstrating CLWA's ability to participate in the Dry Year Program is provided in Appendix 4.8.

**(6) SWP Facilities**

As discussed above, the SWP is a large water supply, storage, and distribution system authorized by the California Legislature in 1959. In 1960, California voters approved the $1.75 billion bond issue to begin building SWP facilities. The SWP currently includes 32 storage facilities, reservoirs and lakes, 17





pumping plants, three pumping-generating plants, five hydroelectric power plants, and about 660 miles of aqueducts and pipelines. Principal SWP facilities are shown in Figure 4.8-18.

The primary purpose of the SWP is to distribute water to 29 urban and agricultural water contractors in Northern California, the San Francisco Bay Area, the San Joaquin Valley and Southern California. The 29 SWP contractor service areas are shown in Figure 4.8-19.

The primary water source for the SWP is within the drainage of the Feather River, a tributary of the Sacramento River. Runoff is stored behind Oroville Dam in Butte County, which is the project's largest storage facility. The water is then released down natural channels to the Sacramento-San Joaquin Delta.

In the southern Delta, water is pumped by the Harvey O. Banks Delta Pumping Plant into the 444 mile-long California Aqueduct. The South Bay Aqueduct, located just south of the Banks Pumping Plant, conveys water to Alameda and Santa Clara counties. Water in the California Aqueduct travels along the west side of the San Joaquin Valley. Some SWP water is stored in the San Luis Reservoir, which is jointly operated by the DWR and the U.S. Bureau of Reclamation. From the San Luis Reservoir, waters in the SWP continue southward.

SWP water then flows south to the Tehachapi Mountains, where the A.D. Edmonston Pumping Plant lifts the water 1,926 feet to enter 10 miles of tunnels and siphons that traverse the Tehachapi Mountains. After crossing the Tehachapis, the aqueduct divides into two branches. The West Branch Aqueduct delivers water to Pyramid and Castaic reservoirs to serve CLWA and other SWP contractors in Southern California. The East Branch Aqueduct flows through the Antelope Valley and delivers water to Silverwood Lake. The water is then transported to San Bernardino and Riverside Counties, and stored in the Lake Perris reservoir.

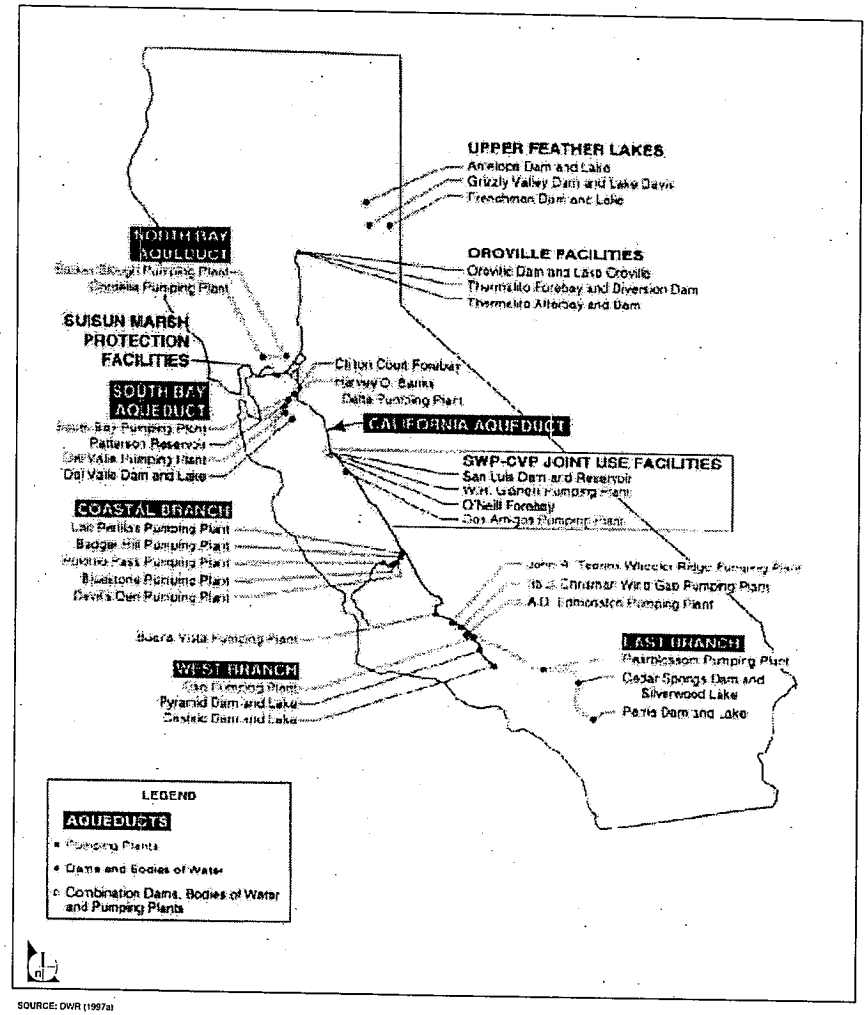
Many other reservoirs add to the storage capacities of the SWP. Table 4.8-7, lists the major storage facilities of the SWP and their storage capacity. In addition to the water storage facilities included in the SWP system, additional storage is available within the SWP contractors' service area (e.g., 800,000 acre-feet of storage in the Diamond Valley Reservoir and 300,000 acre-feet in the Las Posas Basin within the service area of the Metropolitan Water District of Southern California).

**Table 4.8-7**
**Major SWP Reservoirs**

| SWP Division (Location) | Reservoir | Total Storage (AF) |
|---|---|---|
| Oroville Field Division | | 3,762,670 |
| | Frenchman Lake | 55,480 |
| | Antelope Lake | 22,570 |
| | Davis Lake | 64,370 |
| | Oroville Reservoir | 3,537,580 |
| | Thermalito Diversion Pool | 13,350 |
| | Thermalito Forebay | 11,700 |
| | Thermalito Afterbay | 57,040 |
| | Small Storage Facilities | 580 |
| | Aqueduct Pools | 0 |
| Delta Field Division | | 130,909 |
| | Clifton Court Forebay | 31,260 |
| | Bethany Reservoir | 5,070 |
| | Lake Del Valle | 77,110 |
| | Small Storage Facilities | 142 |
| | Aqueduct Pools | 17,327 |
| San Luis Field Division (Joint Use) | | 1,148,967 |
| | O'Neill Forebay (Total Storage = 56,430) | 29,500 |
| | San Luis Reservoir (Total Storage = 2,027,840) | 1,062,183 |
| | Los Banos Reservoir | 34,560 |
| | Little Panoche Reservoir | 5,580 |
| | Small Storage Facilities | 0 |
| | Aqueduct Pools | 17,144 |
| San Joaquin Division | | 27,541 |
| | Small Storage Facilities | 16 |
| | Aqueduct Pools | 27,525 |
| Southern Division | | 979,182 |
| | Silverwood Reservoir | 74,970 |
| | Lake Perris | 131,450 |
| | Quail Lake | 7,580 |
| | Pyramid Reservoir | 171,200 |
| | Elderberry Forebay | 32,480 |
| | Castaic Lake | 323,700 |
| | Castaic Lagoon | 5,560 |
| | Small Storage Facilities | 1,580 |
| | Aqueduct Pools | 230,662 |
| SWP Total | | 6,049,269 |
| | Reservoirs & Small Storage Facilities | 5,756,611 |
| | Aqueduct Pools | 292,658 |

*Source: Data Handbook, State Water Project, 1997.*






SOURCE: DWR (1997a)

FIGURE 4.8-18

Principal State Water Program Facilities

32-101-7/98

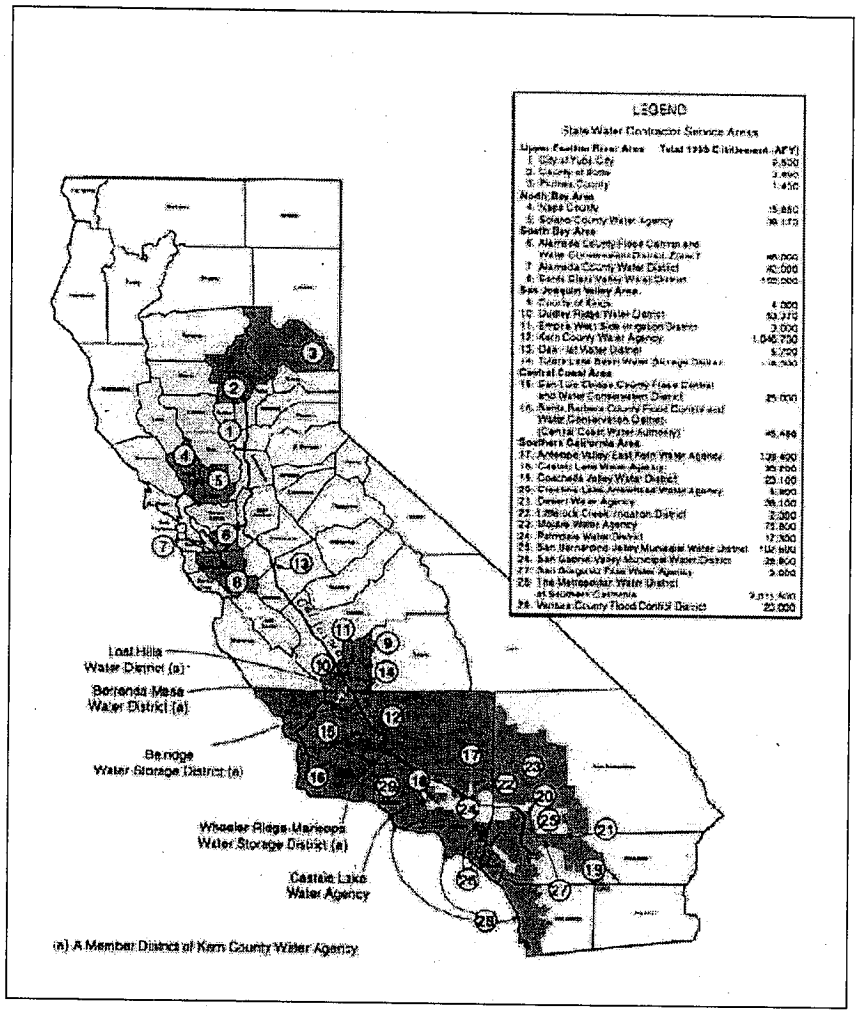



FIGURE 4.8-19

State Water Program Contractor Service Areas

112-16-1

(7) SWP Water Deliveries

**SWP Deliveries.** In the early 1960s, DWR entered into individual water supply contracts with various agricultural and urban water suppliers or contractors. Each contractor (shown previously in Figure 4.8-19) was provided with a contract amount (Table A Amount) and capacity rights to the SWP aqueduct and storage system in return for payments intended to cover operation and maintenance, bondholder obligations and repayment of moneys loaned from the California Water Fund.

DWR water supply contracts require the SWP to deliver 4.2 million AFY to 29 SWP contractors. Although the SWP is not fully constructed and cannot yet deliver the full 4.2 million AFY, since the end of the six-year drought in 1992, the SWP has fully met SWP contractors' water needs every year, except the dry years of 1994 and 2001. Of SWP water deliveries, about 70 percent is delivered to SWP urban contractors and about 30 percent is delivered to SWP agricultural contractors. In 2003, DWR indicated that it can deliver 90 percent (or 3.71 million acre-feet) of SWP Table A Amount to its contractors. Ninety percent of CLWA's SWP maximum Table A Amount of 95,200 AFY equates to 85,680 acre-feet of water.[28] However, as discussed more fully below, the maximum Table A Amount contractually allocated does not necessarily result in equivalent deliveries of SWP water in any given year.

From statewide perspective, the maximum capacity of the overall SWP transportation system is generally limited by the capacity of the system pumps. Therefore, the capacity of the California Aqueduct is 10,300 cubic feet per second (cfs) at its northern end and 4,480 cfs below the Edmonston pumping plant. (1,000 cfs is approximately 82.6 acre-feet per hour, 1,980 acre-feet per day and 725,000 AFY.) If these transportation rates were maintained for a full year, they would result in the transport of approximately 7.2 million acre-feet near the Delta and 3.2 million acre-feet to users in Southern California. Examples of the capacity of the canals and tunnels in the SWP transportation system are shown in Table 4.8-8.

28 DWR NEWS, State Water Project Plans 100 Percent Deliveries, March 14, 2000, (http://wwwdwr.water.ca.gov/dir-dwr...00R2/Mar.14,00-SWP_Full_Deliv.html). The DWR annually issues a series of allocation estimates, starting with conservative estimates in early winter months. Estimates are subject to change during the winter and spring months as more rainfall and snowpack data becomes available. DWR conducts five monthly snow surveys each winter and spring to assess snow conditions and make estimates about snowmelt runoff and future water supply. During the last six years, watersheds feeding the SWP have experienced heavy precipitation, which resulted in high volumes of water delivery through the SWP. Deliveries in wet years typically range around 3 million acre-feet. The current delivery projection is higher than prior years. For example, DWR estimates that the SWP can deliver about 3.71 million acre-feet during calendar year 2003. This current delivery allocation projection, although subject to change, is approximately 90 percent of the maximum Table A Amount requested by SWP contractors. See, Department of Water Resources, State Water Project Delivery Update, Water Deliveries, 2003 State Water Project Allocation Increase, May 16, 2003, http://www.dwr.water.ca.gov/water.html.

Table 4.8-8
Examples of SWP Transportation System Capacity

| Location | Facility or Structure | Design Capacity (cfs) |
|---|---|---|
| Delta Intake | Clifton Court Forebay Channel | 10,300 |
| Near Kings/Kern County Line | SWP Aqueduct Canal | 7,300 |
| Grapevine | SWP Aqueduct Canal | 4,400 |
| South of the Tehachapis and before the East Branch/West Branch Split | SWP Aqueduct Canal | 5,360 |
| West Branch to Castaic Lake | Lower Quail Lake Canal | 1,564 |

*Source: Compiled by Impact Sciences, Inc.*

The local supplies received by CLWA from the SWP are treated, filtered and disinfected at the two existing filtration plants in Santa Clarita Valley. The plants have a current capacity to treat a total of 58 mgd. From the existing plants, the treated water is delivered by gravity throughout the CLWA service area through a distribution network of pipelines and turnouts. One of the existing plants, the Earl Schmidt Filtration Plant, has a current design capacity of 33 mgd. CLWA is currently expanding the plant's treatment capacity to a total of 56 mgd. In addition, the process performance of the plant is being evaluated and will be improved to assure continuous compliance with state and federal water quality regulations. The expanded plant is scheduled to be on-line by mid-2005. CLWA has also begun the design and environmental review process for the expansion of the Rio Vista Water Treatment Plant from 30 to 60 mgd. Ultimate plant design planning by CLWA indicates that the combined treatment capacity of the treatment plants would be approximately 180 mgd.

**(8) SWP Reliability**

The maximum contractual amount of SWP Table A Amounts do not necessarily result in equivalent deliveries of SWP water in any given year. The demands of SWP contractors vary from year-to-year depending on many factors, including the amount of winter rains, agricultural markets, the availability (and cost) of other water resources, municipal and industrial demands and environmental requirements associated with the Sacramento-San Joaquin Delta (Delta), where the water supplied by the SWP originates. To account for these variable supplies and demands, DWR and the SWP contractors have developed a system that annually allows for the identification of the anticipated demands of each SWP contractor (a request of supply) and the system supplies (a DWR allocation of those supplies). Other water resources (Turnback Pool and Interruptible Water) are available from time-to-time to SWP contractors whose needs are not met by the annual allocation of Table A Amounts. The total planned





annual delivery capability of the SWP (approximately 4.2 million acre-feet) is distributed by contract among the 29 SWP contractors, based on their respective contractual Table A Amount. As a result of various factors, the SWP annual deliveries of both Table A Amount water and non-Table A Amount water have ranged from approximately 550,000 acre-feet to 3.52 million acre-feet (DWR 2003). In 1999, the SWP delivered approximately 3.1 million AFY of both Table A Amount and non-Table A Amount water. The SWP delivered approximately 3.5 million acre-feet of Table A Amount and non-Table A Amount water in 2000.[29] In 2003, DWR indicates that it can deliver 90 percent (or 3.71 million acre-feet) of the maximum contractual SWP Table A Amount to its contractors. Ninety percent of CLWA's maximum SWP Table A Amount of 95,200 AFY equates to 85,680 acre-feet of water.

CLWA's current maximum SWP Table A Amount of 95,200 AFY is affected by, and can be reduced due to, a number of factors, including hydrologic conditions, the status of SWP facilities' construction, environmental requirements and evolving policies for the Delta. Because of these factors, SWP supplies are subject to reduction, particularly during drought periods. The programs listed below have the potential to improve the reliability of SWP water.

**Monterey Agreement/Amendments.** As discussed above, the Monterey Agreement between DWR and the agricultural and urban contractors provides substantial opportunities for SWP contractors, including CLWA, to increase water management flexibility by providing more tools to maximize the use of existing facilities and, in doing so, increase water supply reliability. The Monterey Agreement changed SWP water allocation rules by specifying that, during drought years, project supplies are to be allocated proportionately based on the maximum contractual Table A Amount. Water is allocated to urban and agricultural purposes on a proportional basis, deleting a previous initial supply reduction to agricultural contractors. The agreement further defines and permits permanent sales of SWP Table A Amounts and provides for transfer of up to 130,000 acre-feet of annual Table A Amounts from agricultural use to municipal use, of which CLWA has purchased 41,000 acre-feet. The Agreement also allows SWP contractors to store water in another agency's reservoir or groundwater basin, facilitates the implementation of water transfers and provides a mechanism for using SWP facilities to transport non-project water for SWP water contractors. The Agreement provides greater flexibility for SWP contractors to use their share of storage in SWP reservoirs. CLWA currently has access to about 4,700 acre-feet of storage in Castaic Lake.

**CALFED Bay Delta Program.** The CALFED Bay Delta program is a cooperative state-federal process with the goal of developing a long-term solution to the many competing water needs of the Sacramento-

29 The State Water Project Delivery Reliability Report, 2003, Final, found at http://swpdelivery.water.ca.gov.

San Joaquin Bay-Delta. The program is a 30-year, three-phased effort addressing a number of issues including ecosystem quality, water quality, water system reliability and system vulnerability. Implementation of the CALFED improvements over time can significantly improve CLWA's ability to maintain delivery of high quality water and provide needed water supplies during dry years.

**Interim Delta Improvements.** Potential supply development for the SWP includes interim Delta improvements that involve: (1) south Delta channel enlargements and construction of four barriers to improve south Delta flow circulation; and (2) installation of acoustic fish barriers on the Sacramento River. The interim improvements would enable the use of additional pumps at Banks Pumping Plant when flow conditions are sufficient, and permit the relaxation of certain current operational constraints. It is also anticipated that these improvements would change the Delta fisheries on a positive basis. Therefore, the expected supply yield would improve. Although this solution is considered viable and cost-effective, it does not constitute a permanent solution to the Delta.

**Full Delta Fix.** As the overall demand for water increases and the need for low-salinity imported water intensifies, a long-term solution to the Delta becomes critical. It is expected that a Delta transfer facility would provide a long-term solution to Delta problems, increase supply reliability, reduce habitat impacts and improve the water quality of Delta diversions. Goals would be to minimize the effects of the SWP export pumps on Delta fisheries and greatly improve the quality of the exported water.

**South of Delta Storage.** The potential exists for additional storage south of the Delta. This storage could include both reservoir projects and groundwater banking/conjunctive-use storage. The reliability of the SWP supply would increase significantly, especially during dry years, with the development of south of Delta storage. However, the benefits of the storage would be maximized if a full Delta fix were implemented. As part of the CALFED analysis, approximately 3 million acre-feet of total storage capacity could be implemented south of the Delta.

**Figure 4.8-20 and Table 4.8-9**, below, summarize the variability in SWP supplies available to CLWA by the year 2020 under the following different CALFED improvement scenarios:

(a) **Under Existing Conditions,** based on the DWRSIM model and historical hydrologic conditions, CLWA would receive approximately 37,900 acre-feet about 10 percent of the time (which is considered to be in a dry period) and approximately 56,800 acre-feet about 50 percent of the time (which is considered to be in average/normal rainfall periods).

(b) **Under Interim Delta Improvements,** CLWA would receive approximately 40,200 acre-feet about 10 percent of the time and approximately 73,700 acre-feet about 50 percent of the time.

(c) **Under a Full Delta Fix,** CLWA would receive approximately 63,900 acre-feet about 10 percent of the time and approximately 95,200 acre-feet about 50 percent of the time.





(d) **Under a South of Delta Storage,** CLWA would receive its full Table A Amount about 50 percent of the time.

**Figure 4.8-20**
**Projected State Water Deliveries**

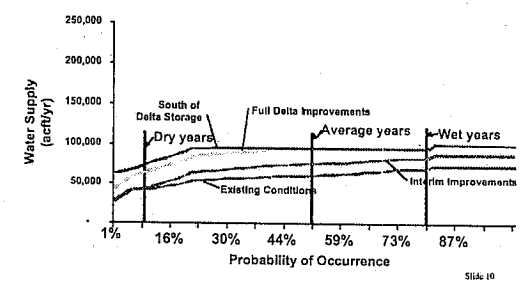



**Table 4.8-9**
**Projected State Water Project Supplies**
**(acre-feet per year)**

| | Wet-Year | Average/Normal Year (50% Occurrence) | Dry-Year (10% Occurrence) |
|---|---|---|---|
| Existing Conditions | 66,300 | 56,800 | 37,900 |
| Interim Delta Fix | 82,900 | 73,700 | 40,200 |
| Full Delta Fix | 95,200 | 95,200 | 63,900 |
| South of Delta Storage & Full Delta Fix | 95,200 | 95,200 | 75,800 |

*Based on DWRSIM modeling (assuming full requests for all contractors).*

**DWRSIM and CALSIM II - Modeling Results.** As stated above, the amount of water available to CLWA was calculated through the use of computer models, commonly known as the DWRSIM model and the CALSIM II model. The DWRSIM model, developed by DWR, was used to forecast CLWA water supply under various meteorological and land use changes as well as regulatory constraints. The reliability analysis derived from the DWRSIM model generally provides a conservative projection of SWP operations. For example, SWP delivery projections are usually based on *advance* requests reported by

SWP contractors. These requests generally overstate the *actual* need for SWP deliveries. Therefore, there is additional SWP water available for actual distribution despite the DWRSIM modeling results shown above. In addition, as a mathematical model, DWRSIM is limited to the amount of water actually requested and does not include water available in excess of requests. Therefore, as noted below, the modeling results should be supplemented with information based on historic availability of additional SWP water supplies.

DWR has prepared a new computer model, known as CALSIM II. CALSIM II simulates the operation of the SWP on a monthly basis over a 73-year historical record of rainfall and runoff (1922 – 1994). When compared with DWRSIM, CALSIM II forecasts that more water will be available in average/normal years (i.e., 59.7 percent under DWRSIM versus 75 percent under CALSIM) and less water will be available in single critical dry years (i.e., 39.8 percent under DWRSIM versus 20 percent under CALSIM). The analysis presented in this document utilizes a worst-case combination of the DWRSIM and CALSIM II models. (See, DWR's The State Water Project Delivery Reliability Report, Final, dated May 2003, attached to this analysis in Appendix 4.8 for a complete description of the CALSIM II model.)

Historically, the SWP has delivered water in excess of SWP contractors' requests. From 1962 to 1999, the SWP delivered water in excess of the SWP contractors' requests in all but four years.

**Drought Water Bank.** Another program with the potential to improve the reliability of SWP water in drought periods is the state's Drought Water Bank. The Drought Water Bank is implemented as needed by an Executive Order by the Governor, or a finding by the DWR's director that water deliveries will be curtailed. The purpose of the Bank is to help California's urban, agricultural and environmental interests meet their water supply needs during dry years. The procedure was used successfully in 1991, 1992 and 1994 when DWR purchased water from willing sellers and sold the water to willing buyers under a set of allocation guidelines. However, in future dry years, the use of the state's Drought Water Bank would have to take into consideration local groundwater management ordinances, which restrict or control groundwater export. The proliferation of these local ordinances makes it less likely that the state's Drought Water Bank would rely on water transfers involving groundwater export in future dry years.

**Drought Planning.** In addition to the Drought Water Bank, the CALFED Record of Decision (August 28, 2000) called for the Governor to convene a panel, chaired by the DWR director, to develop a contingency plan for reducing the impacts of critical water shortages primarily for agricultural and urban water users. The contingency plan, known as the Governor's Advisory Drought Planning Panel, Critical Water Shortage Contingency Plan, December 29, 2000, building upon experience gained from implementing the Drought Water Bank, identifies available water resources (e.g., water transfers, water exchanges,





groundwater programs) and funding mechanisms to minimize the impacts created by drought conditions. The plan has been completed, circulated for public comment and finalized.

The contingency plan provides a brief background on California's water supplies and the hydrologic conditions potentially associated with critical water shortages. Chapter 2 describes changed water management conditions since the most recent statewide drought of 1987-1992. Chapter 3 describes the challenges in dealing with critical water shortages given these changed conditions. The challenges include constraints on availability and capacity of conveyance and storage facilities, regulatory restrictions and uncertainties, competition for limited water supplies among existing water purchasing programs and other identified issues. Chapter 4 presents the panel's recommendations for actions to be undertaken to address critical water shortages.

In the plan, the panel focused on the significant water management changes that have occurred since the statewide drought in 1987–1992. These developments include changes in water demand due to population growth, changes in institutional conditions affecting use of surface water and groundwater, construction of new water supply facilities, legislative changes and pending implementation of CALFED actions.

Since the last statewide drought of 1987–1992, two of the beneficial changes that have occurred in California are the construction of new water supply facilities and an expansion in groundwater recharge/storage capacity. Table 4.8-10, below, shows the major water conveyance facilities constructed or under construction since the last statewide drought.

Table 4.8-10
Large-Scale Conveyance Facilities Constructed Since the Last Drought

| Facility | Agency | Length (miles) | Maximum Capacity (cfs) |
|---|---|---|---|
| Coastal Branch Aqueduct | Department of Water Resources | 100 | 100 |
| Eastside Reservoir Pipeline | Metropolitan Water District of Southern California | 8 | 1,000 |
| East Branch Enlargement | Department of Water Resources | 100 | 2,100 |
| | (this phase increased existing capacity by approximately 750 cfs) | | |
| Mojave River Pipeline | Mojave Water Agency | 70 | 94 |
| Old River Pipeline (Los Vaqueros Project) | Contra Costa Water District | 20 | 400 |
| East Branch Extension (under construction) | Department of Water Resources | 14 | 104 |
| Inland Feeder Project (under construction) | Metropolitan Water District of Southern California | 44 | 1,000 |
| Morongo Basin Pipeline | Mojave Water Agency | 71 | 100 |
| New Melones Water Conveyance Project (Farmington Canal) | Stockton East Water District and Central San Joaquin Water Conservation District | 21 | 500 |

*Source: Critical Water Shortage Contingency Plan, Governor's Advisory Drought Planning Panel, December 29, 2000.*

In addition, there has been an expansion in groundwater recharge/storage capacity since the last statewide drought. **Table 4.8-11**, below, describes some of the larger groundwater recharge/storage projects currently operating in California. The projects that are now operational since the last drought are those operated by the Semitropic Water Storage District, the Arvin-Edison Water Storage District, the Kern Water Bank Authority, the Mojave Water Agency and the Calleguas Municipal Water District. These groundwater recharge/storage projects rely either wholly or in part on recharge supplies from the SWP. Therefore, the project's operations are subject to SWP restrictions in drought periods, as well as the availability of conveyance capacity. If water transfers provide a component of recharge supplies, availability of SWP conveyance capacity becomes a limiting factor (Contingency Plan, November 2000). As discussed above, the maximum capacity of SWP storage and conveyance facilities is extensive (4.2 million acre-feet); however, those facilities have not been completed. This capacity has been enhanced by the aforementioned groundwater recharge/storage facilities since the statewide drought of 1987–1992.





Table 4.8-11
Examples of Groundwater Storage Projects

| Agency and Project Location | Comments |
|---|---|
| Alameda County Water District Niles Cone, Alameda County | Seawater intrusion management and conjunctive use, District recharges local runoff and imported surface supplies from its SWP 42 taf annual contractual Table A Amount. Average annual recharge of 25 taf. |
| Arvin Edison Water Storage District Kern County | A 350 taf banking program is being developed with MWD. Estimated extraction capability is 40 to 75 taf/year. |
| Calleguas Municipal Water District Las Posas Basin, Ventura County | Uses injection wells to recharge its imported MWD supplies. Maximum storage capacity of 300 taf. At full implementation, maximum annual extraction rate estimated to be 72 taf. Providing local emergency storage is a major project purpose. |
| City of Bakersfield Kern River Fan Area, Kern County | Initial operation of 2,800-acre recharge facility began in 1978. City has rights to Kern River water, and long-term contracts with three water agencies that store and extract water in coordination with the city. |
| Coachella Valley Water District Upper Coachella Valley, Whitewater River Channel Area | Recharge from local Whitewater River supplies and from MWD's imported Colorado River Aqueduct water exchanged for SWP contractual Table A Amounts of CVWD and Desert Water Agency. |
| Kern Water Bank Authority Kern River Fan Area, Kern County | 6,800 acres of recharge basins. The Authority is a joint powers agency that operates the project on behalf of local water agencies. Recharge supplies may be local surface water or imported supplies. |
| The County of Los Angeles Department of Public Works, Los Angeles River and San Gabriel River watersheds, Los Angeles County | Extensive recharge facilities employing about 2,400 acres of spreading areas, and injection wells at three seawater intrusion barriers (Alamitos, Dominguez Gap, and West Coast). County operates the river systems for the dual purpose of flood control and groundwater recharge, and also recharges imported and reclaimed water provided by others. |
| Monterey County Water Resources Agency Salinas River Valley, Monterey County | Releases from MCWRA's Nacimiento and San Antonio Reservoirs are managed to provide recharge for upper valley. MCWRA distributes reclaimed water produced by the Monterrey Regional Water Pollution Control Agency for in-lieu recharge in the lower valley, to help reduce seawater intrusion. MCWRA's 45-mile distribution system can convey 19.5 taf of reclaimed water. |
| Mojave Water Agency Mojave River Basin, San Bernardino County | Basin has been adjudicated by court. The ephemeral Mojave River is the only local surface supply. To reduce overdraft, MWA's two new 71-mile pipelines import SWP supplies for recharge in spreading areas in the river channel. MWA's initial SWP contractual Table A Amount of 50.8 taf annually was augmented by the 1997 purchase of an additional 25 taf of annual Table A Amount. |
| Pioneer Project, Kern County Water Agency, Kern County | Recharge project with 1,200 acres of ponds capable of recharging 146 taf per year. Annual recovery capacity of 98 taf. Estimated storage of 400 taf. Project began operation in 1995. |
| Orange County Water District Santa River Watershed, Orange and Riverside Counties | Recharges Santa Ana River water regulated at Prado Dam, also recharges reclaimed water. Operates series of recharge basins along lower river and two seawater intrusion barriers. One barrier is jointly operated with the County of Los Angeles. Typically recharges about 300 taf annually. |
| Santa Clara Valley Water District Santa Clara County | District formed in 1929 to combat declining groundwater levels and associated land subsidence. Has 20 recharge basins covering about 390 acres, and also recharges in stream channels. District typically recharges over 100 taf annually, with a combination of local and imported supplies. Estimated operational storage is 550 taf. |
| Semitropic Water Storage District Kern County | Banking (in-lieu recharge) program with one maf storage capacity. Banking partners include MWD (350 taf), Santa Clara Valley WD (350 taf), Alameda County WD (50 taf), Zone 7 Water Agency (65 taf), Vidler Water Company (185 taf), The Newhall Land and Farming Company and the Castaic Lake Water Agency. |
| United Water Conservation District Santa Clara River Watershed, Ventura County | Operates Lake Piru on Piru Creek and Freeman Diversion Dam on the Santa Clara River in conjunction with spreading areas at Saticoy, El Rio and Piru. |
| Zone 7 of Alameda County Water Conservation and Flood Control District Alameda County | Recharges imported SWP water (46 taf annual contractual Table A Amount) in local stream channels. |

*Source: Critical Water Shortage Contingency Plan, Governor's Advisory Drought Planning Panel, December 29, 2000.*

(9) SWP - Other Water Deliveries

In addition to delivering Table A Amounts to the SWP contractors, the SWP conveys water to and stores water for contractors and other public agencies through other contracts and programs. (DWR Bulletin 132-98, November 1999, Ch. 9) These contracts and programs include, for example, the following:

**Turnback Water Pool Program.** Under Article 56(d) of the Monterey Amendments, the Turnback Water Pool Program was initiated through Notice to the SWP Contractors No. 97-3, dated February 5, 1997 (DWR Bulletin 132-98, November 1999, Ch. 9) All SWP contractors who signed Monterey Amendments are permitted to participate in the program. The program allows SWP contractors to offer a portion of their approved Table A Amounts for sale in a turnback pool for use outside their service area. Other contractors interested in purchasing this water can then request a portion or all of it. Based on supply and demand, the turnback water is then allocated between the selling and purchasing contractors. This program allows "excess" water to be made available to SWP contractors throughout the State of California.

**Interruptible Water Program.** The Interruptible Water Program allows an SWP contractor to take delivery of water over the approved and scheduled allocations for the current year. Interruptible water is available for delivery on a short-term basis as determined by the DWR, when scheduled project demands are being delivered and operational requirements for project water deliveries, water quality and other requirements are being met. (DWR Bulletin 132-98, November 1999, Ch. 9) CLWA is one of the SWP contractors that can participate in this program based upon its proportionate maximum Table A Amount.

**Surplus Water Provisions.** Pursuant to the Monterey Amendments, the Surplus Water Provisions allow certain SWP contractors to take delivery of "surplus" water; that is, water in excess of that required to meet all demands for Table A water. CLWA is one of the SWP contractors that can avail itself of surplus water as needed based upon its proportionate Table A Amount.

**Carryover Water.** For several years, DWR has offered SWP contractors the opportunity to carryover a portion of their undelivered Table A Amounts from one year for delivery during the next year. The carryover program was designed to encourage the most effective and beneficial use of water and to avoid obligating the contractors to use or lose the water by December 31 of each year. The SWP contractors' long-term water supply contracts and amendments state the criteria of carrying over Table A Amounts from one year to the next. CLWA is one of the SWP contractors that can avail itself of carryover water. In 1997, 263,759 acre-feet of carryover water was approved by DWR for future delivery to SWP contractors. (DWR Bulletin 132-98, November 1999, Ch. 9)





Both CLWA's SWP Table A Amount and SWP water from the foregoing programs are water supply sources that could be used in groundwater banking programs. These water supply sources are available during average/normal years for injection or "banking" in groundwater basins. The stored water can then be pumped when SWP supplies are reduced in dry years. In particular, these water supply sources could be available from CLWA for use in the Semitropic Groundwater Banking Project, which is discussed in further detail below.

## e. Groundwater Banking and Conjunctive-Use Projects

With recent developments in conjunctive-use and groundwater banking programs, there are significant opportunities currently exist to improve the reliability of local and imported water supplies in Santa Clarita Valley. The term "conjunctive-use" generally means the coordinated operation of multiple water supplies to achieve improved supply reliability. Most conjunctive-use concepts are based on storing water supplies in times of surplus for use in times of drought. A typical program involves importation of additional surface supplies from the SWP during wet periods, recharging the water in a local groundwater basin and pumping out the stored water from wells when SWP supplies are reduced during a drought.

Groundwater banking programs generally involve storing available SWP supplies during wet years in groundwater basins (e.g., the San Joaquin Valley and the Saugus Formation). The water would be stored either directly by surface spreading or injection/extraction wells, or indirectly by supplying surplus SWP water to farmers in-lieu of groundwater pumping for agricultural uses. During dry periods, the stored water could be pumped out and exported to the Aqueduct, or used by farmers in exchange for their surface water allocations and delivered to CLWA through SWP facilities. Several potential conjunctive use and groundwater banking opportunities are available for use in the Santa Clarita Valley. Upon implementation, such programs can provide the following significant benefits in terms of water management and planning:

(a) A location to store available supplies in wet years, thus maximizing the efficient use of water resources;

(b) A dry-year supply that augments existing supplies reduced by drought or other shortages; and

(c) A storage "reservoir" that can be drawn upon when supplies are insufficient during unforeseen emergencies.

These benefits allow such programs to "firm up" and enhance the reliability of both existing and future water supplies. **Table 4.8-12** below summarizes the projected water supply benefits for each of the identified groundwater banking and conjunctive use projects projected by CLWA.

**Table 4.8-12**
**Projected Groundwater Banking and Conjunctive-Use Supplies – CLWA (2020)[1]**
**(acre-feet per year)**

| Source | Dry Year |
|---|---|
| Kern Water Bank | 25,000 |
| Semitropic Water Bank | 30,000 |
| Kern Delta Water Bank | 40,000 |
| North Las Posas Water Bank | 10,000 |
| Total | 105,000 |

[1] *Assumes Groundwater Banking Programs would only be called on in dry-years. All groundwater banking programs are available in wet and average/normal years. In 2010, the amount of supply expected from groundwater banking and conjunctive use projects is approximately 50,000 AFY.*

Ongoing groundwater banking programs include the Kern Water Bank, the Semitropic Water Storage District, the Kern Delta Water District and the North Las Posas Water Bank. Each program is discussed in further detail below.

**Kern Water Bank.** The Kern Water Bank was established by DWR in 1988 as a statewide conjunctive-use program to increase the yield and enhance the reliability of the SWP. Eight elements were identified, seven sponsored by local agencies with the eighth being DWR's Kern Fan Element. The Kern Fan Element (later transferred to Kern Water Bank Authority) included the purchase of 19,900 acres of land and construction of recharge basins, extraction wells and related facilities. The original plan was to store SWP water underground in years of abundant supply and extract the banked water in dry years for use by SWP contractors. This original plan was divided into elements, such as Kern Fan, Semitropic and Cawelo. Initial studies indicated that the Kern Fan Element could store as much as 1,000,000 acre-feet of water and provide up to 140,000 acre-feet of water to the SWP in dry years. The other seven elements vary significantly in size. The Semitropic Local Element is the largest of these with more than 1,000,000 acre-feet of storage, while Cawelo Water District is the smallest with a storage capacity of about 110,000 acre-feet. The Semitropic element is discussed further below.

In 1994, the Kern Water Bank Authority (KWBA) was established to develop and operate the Kern Water Bank. The KWBA is a joint powers authority consisting of six water agencies. The KWBA constructed recharge basins and began recharging water in 1995. KWBA is now constructing additional basins, extraction wells and water conveyance facilities.





In October 1997, the KWBA, in conjunction with state and federal fish and wildlife agencies, established a Habitat Conservation Plan and Natural Community Conservation Plan that is preserving wildlife in the area while ensuring an adequate water supply for the future. When the KWBA's new water recharge facilities are completed, they will provide Kern County farming interests with the capability of storing more than 1,000,000 acre-feet of water on a permanent basis. Currently, more than 760,000 acre-feet is in storage.

**Semitropic Water Storage District.** The Semitropic Water Storage District (also referred to as "Semitropic" or "District") provides SWP for irrigation. The District is located in the San Joaquin Valley in the northerly part of Kern County immediately east of the California Aqueduct. Using the immense groundwater storage capacity available to Semitropic (one million acre-feet), the District has developed a groundwater-banking program. The District operates the program by taking additional SWP supplies in wet years and returning the water in dry years. As part of this dry-year return, Semitropic can leave its Table A Amount in the Aqueduct and increase its groundwater production. Semitropic has also constructed facilities so that groundwater can be pumped into their canal and, through reverse pumping plants, actually delivered to the California Aqueduct. Semitropic currently has six banking partners: the Metropolitan Water District, Santa Clara Valley Water District, Alameda County Water District, Alameda County Zone 7, Vidler Water Company and The Newhall Land and Farming Company. The total amount of storage under contract is approximately 1,000,000 acre-feet. The stored water may be extracted in annual amounts of up to 90,000 acre-feet for all banking partners except Newhall; Newhall can extract up to 4,950 AF annually from the bank. In 2002, CLWA entered into an agreement with DWR and the Kern County Water Agency for the interim banking of water in Semitropic.

In addition, Semitropic has recently completed environmental documentation to construct new storage and return facilities. These new facilities will provide Semitropic with the additional capability to extract and pump-back to the California Aqueduct approximately 200,000 acre-feet annually. The total return capability of Semitropic in dry years is expected to be approximately 290,000 acre-feet.

**Kern Delta Water District.** Kern Delta Water District is in the process of developing a banking agreement with the Metropolitan Water District. Kern Delta is in the San Joaquin Valley southwest of Bakersfield and obtains imported supplies from the Kern River, 180,000 acre-feet of pre-1914 rights, and the SWP under contract through Kern County Water Agency for a maximum annual Table A Amount of 25,000 acre-feet. Under the proposed Kern Delta banking program, in wet years, additional water would be supplied to Kern Delta where it would augment groundwater supplies through either direct groundwater recharge by spreading or by in-lieu replenishment. In dry years, previously stored supplies would be returned to the Metropolitan Water District, either by direct groundwater pumpback or

through exchange of other supplies available to Kern Delta. Total return capability in dry years would be 40,000 acre-feet, with a total storage capacity of 200,000 to 240,000 acre-feet.

**North Las Posas Water Bank.** The North Las Posas Groundwater Basin is about 18 miles long and 4.5 miles wide, and is located in Southern California near Los Angeles. Water to this area is supplied by the Calleguas Municipal Water District, which imports all of its water from the Metropolitan Water District.

Investigations have shown that the North Las Posas Groundwater Basin has available storage capacity of about 300,000 acre-feet, primarily as a result of historic groundwater production. It is projected that the North Las Posas Water Bank could be used to return up to 10,000 acre-feet of previously stored water when needed.

### f. Water Transfers

Another opportunity available to CLWA for increasing water supplies and enhancing reliability is to participate in voluntary water transfer programs (UWMP, Ch. 2.0). Since the statewide drought of 1987-1992, water transfers have developed into a viable supplemental source to improve supply reliability. The initial concept for water transfers was codified into law in 1986 when the California Legislature adopted the "Katz" Law (California Water Code Sections 1810-1814) and the Costa-Isenberg Water Transfer Law of 1986 (California Water Code Sections 470, 475, 480-483). These laws help to define the parameters for water transfers and establish a variety of approaches through which water or water rights can be transferred among individuals or agencies.

A water transfer can involve water sales, water ranching/farming and water sharing, and usually occurs as a form of spot, option and core transfers agreements. The cost of water transfer varies depending on the type, term and location of the transfer. Up to 27 million acre-feet of water are delivered for agricultural use every year. Over half of this water is in the Central Valley, and much of it is delivered by, or adjacent to, SWP and Central Valley Project conveyance facilities. This allows for the voluntary transfer of water to many urban areas through SWP facilities, including the CLWA service area.

One of the most important aspects of any resource planning process is flexibility. A flexible strategy minimizes unnecessary or redundant investments (or stranded costs). The voluntary purchase of water between willing sellers and buyers can be an effective means of achieving flexibility. However, not all water transfers have the same effectiveness for ensuring flexibility. Within the resource planning process and through ultimate implementation, several different types of water transfers have been undertaken:





**Core Transfers.** Agreements to purchase a defined quantity of water every year, whether needed or not. These transfers have the benefit of more certainty in costs and supply, but tend to offset surplus imported water (available in most years) that is already paid for.

**Spot Market Transfers.** Water that is purchased only during the time of need (usually a drought). Payment for these transfers occurs only when water is needed, but there is usually greater uncertainty in terms of costs and availability of supply. An example of such a transfer was the state's Drought Water Bank. An additional risk of spot market transfers is that the purchase may be subject to institutional limits or restricted access (e.g., requiring the purchasing agency to institute rationing before it is eligible to participate in the program).

**Option Contracts.** Agreements that specify the amount of water needed and the frequency or probability that the supply will be called upon (an option). These transfers have the best characteristics of both core and spot transfers. With option contracts, the potential for redundant capacity is minimized, as are the risks associated with cost and supply availability.

The most viable types of water transfers are core and option transfers and, as such, represent the CLWA's long-term strategy. (UWMP, Ch. 2.0) The costs for these types of transfers have been estimated to be about $60 to $160 per acre-foot for core transfers (compared to the initial cost of $1,100 to $2,000 per acre-foot for SWP Table A water), and $250 per acre foot for option transfers. Although the option transfer costs might seem high, the equivalent average annual cost is much less, about $65 to $112 per acre foot. The reason the average annual option transfer costs are much lower is due to the variable likelihood that the transfers will be needed.

### g. Water Exchanges: Brackish and Seawater Desalting

Water exchanges represent the use of water that belongs to another entity either by trading water for water or by paying the cost of the water development and transmission. One opportunity for future exchange is through brackish and seawater desalting. (UWMP, Ch. 2.0)

Large-scale seawater desalination processes usually occur by one of two means: membrane processes and thermal processes. Membrane processes such as reverse osmosis (RO) use pressure to push seawater through semi-permeable membranes. The membrane acts as a filter allowing water to pass but not dissolved solids and impurities. Thermal processes utilize heat to separate the water from the salt and other impurities in the seawater. Thermal facilities tend to be more common but are often located in

areas where fuel is inexpensive. Therefore, as membrane technology closes the cost gap, RO will become a less costly and more energy efficient desalination technology.

Desalination of seawater is technically feasible, but has historically been an expensive procedure. However, recent seawater desalination projects seem to indicate that the cost of seawater desalination, in some site-specific situations, has decreased in recent years. The competitive proposal process for the design, construction, and operation of the 25 mgd Tampa, Florida, seawater desalination plant gained worldwide attention. The best and final offer had a first year water cost of $560.00/acre-feet and a 30-year nominal cost of water of $680.00/acre-feet. This compares favorably to past desalination costs reported to be in the range of $1,300.00 to over $2,000.00 per acre-feet. The Tampa project includes a number of favorable factors that contribute to the low water price.

In Trinidad, a 23-year contract was awarded to build, own, and operate a 28.8 mgd seawater desalination facility. The plant will supply water at a first-year price of $865.00/acre-feet (1999).

A third example is the Long Beach Desalination Project, currently in the planning stages. Poseidon Resources, the Long Beach Water Department and Southern California Edison are key participants in this project. The project includes a 20-40 mgd desalination plant and appurtenant facilities. The $90 to $180 million private investment will present no financial risk to the public partners, while at the same time providing substantial water supplies.

Current projects would seem to indicate that the cost of seawater desalting is at a point where it could become a viable resource option. As discussed above, 20,000 to 40,000 AFY will be available as part of the proposed Long Beach project. CLWA has assumed that between 2,000 and 5,000 AFY of desalted water could be purchased for use in the CLWA service area.

## h. Water Conservation and Water Supply Planning

In recent years, water conservation has become an increasingly important factor in water supply planning (UWMP, Ch. 5.0, 7.0). Although not considered a "supply" source, water conservation measures have the same effect by reducing overall water demand, making more water available for use at the local and state level. In the Santa Clarita Valley, CLWA and the four retail water purveyors have actively implemented water conservation programs for many years, and additional programs are planned for the future. (UWMP, Ch. 5) CLWA is now a signatory to the Urban Water Conservation Council Memorandum of Understanding regarding the use of best management practices.





In summary, CLWA and the purveyors have developed extensive water conservation efforts, and the CLWA service area has achieved significant reductions in actual water usage through these programs. During the early 1990s (hot/dry period), the overall water requirements, due to the effects of weather, were projected to increase by approximately 10 percent. As a result of the conservation efforts, the overall water requirement actually decreased by 20 percent.

CLWA has adopted the water conservation goal of an overall 10 percent reduction in normal demand. Residential and commercial water usage can be expected to decrease through the implementation of existing and future programs. CLWA and the purveyors assume that water conservation can decrease water usage in normal years by approximately 10 percent (which is considered a conservative estimate).

**Water Demand Measures and Best Management Practices.** The Urban Water Management Act lists 14 Demand Management Measures that correspond to the 14 urban Best Management Practices ("BMPs"), or water use efficiency measures, promulgated by the California Urban Water Conservation Council. Adoption of the BMPs is presently voluntary; about 250 water agencies throughout the state have committed to implement them.

The recent CALFED Bay-Delta Program required mandatory adoption of the BMPs by December 2002. The water agencies of the Santa Clarita Valley have committed to implement the BMPs.

**Implementation of Best Management Practices.** The Demand Management Measures/Best Management Practices that are currently being implemented by the Santa Clarita Valley water agencies, or planned for implementation, are listed below.

- **Water Survey Programs for Single and Multi-Family Residential Customers.** The programs target and market the identified residential customers. The water agencies in Santa Clarita Valley will continue to implement these surveys and later implement the BMP.
- **Residential Plumbing Retrofit.** The program identifies residences constructed since 1992 and develops distribution strategy for water saving devices. The water agencies in Santa Clarita Valley will continue to implement this program and later implement the BMP.
- **System Water Audits, Leak Detection and Repair.** This programs involves leak detection and repair. The water agencies in Santa Clarita Valley will continue to implement this activity.
- **Metering with Commodity Rates for New Connections and Retrofit of Existing Connections.** The metering of all new connections and retrofitting is already done by agencies in Santa Clarita Valley.
- **Large Landscape Conservation Programs and Incentives.** These programs offer water use surveys to non-residential customers with large landscape areas. The water agencies in Santa Clarita Valley are partially complying with this activity, and will later implement the BMP.

- **High Efficiency Washing Machine Rebate Program.** This program offers rebates for purchase of horizontal-axis washing machines. The water agencies in Santa Clarita Valley do not offer rebates (nor do local energy providers or wastewater agencies). Local agencies are exempt from implementation.

- **Public Information Program.** This program implements an appropriate public information program on water efficiency. The water agencies in Santa Clarita Valley offer a very extensive and effective, award-winning program.

- **School Education.** This program provides water efficiency classes and information to schools. The water agencies in Santa Clarita Valley offer an extensive and effective award-winning program.

- **Conservation Programs for Commercial, Industrial, and Institutional (CII) Customers.** These programs identify such accounts, rank them according to water use and offer water use surveys and incentives. The water agencies in the Santa Clarita Valley not yet implementing the programs will implement the BMP at a later date.

- **Wholesale Agency Programs.** CLWA provides financial incentives or equivalent to retailers, along with technical support and information. Local water agencies will continue to implement this activity.

- **Conservation Pricing.** The water agencies in the Santa Clarita Valley institute conservation pricing. Local agencies will continue to implement a variety of pricing structures that meet the terms of this requirement.

- **Water Conservation Coordinator.** The water agencies in the Santa Clarita Valley designate staff to oversee water conservation program implementation. Local agencies will continue to implement.

- **Water Waste Prohibition.** CLWA enforces measures prohibiting water waste; however, CLWA does not possess police powers.

- **Residential Ultra-Low-Flow Toilet (ULFT) Replacement Program.** The programs determine number of service connections constructed before 1992 and offer toilet replacements. Local agencies will implement this BMP at a later date.

In September 2003, CLWA developed a long-term Draft Report, Water Supply Reliability Plan. A copy of this document can be found in Appendix 4.8 of this EIR. The primary objectives of the draft Water Supply Reliability Plan are to develop a protocol to identify current opportunities, evaluate opportunities using uniform economic criteria, and recommend a water supply reliability plan that focuses CLWA's efforts on the cost effective and beneficial opportunities. The recommended draft Water Supply Reliability Plan includes the following primary elements:

- Near-term acquisition of water banking capacity to allow banking of excess SWP water until the selected long-term banks have been developed.
- Acquisition of water banking capacity south of the Tehachapi Mountains to provide reliability for potential SWP conveyance disruptions.





- Acquisition of water banking capacity north of the Tehachapi Mountains to meet the additional identified water banking requirements not provided south of the Tehachapi Mountains.

The draft Water Supply Reliability Plan also includes a discussion of key implementation issues and a recommended implementation plan. The Plan recommends that CLWA provide a minimum storage capacity of 50,000 acre-feet by 2005, rising to 183,000 acre-feet by 2050. For additional information regarding these topics, please see the plan in Appendix 4.8.

### i. Local Water Contingency Planning

In addition to the conservation programs, during the 1991 drought year, the local water agencies in the Santa Clarita Valley prepared and implemented a Water Shortage Contingency Plan. It was again implemented in 1994 due to the Northridge earthquake. In both instances, the Contingency Plan worked effectively. The summary provided below describes various aspects of the updated Water Shortage Contingency Plan for the Santa Clarita Valley. (UWMP, Ch. 6.0)

**Drought Committees.** In past droughts, two committees were formed to address drought conditions: the Upper Santa Clara Valley Water Committee, consisting of the local water agencies in the Santa Clarita Valley, and the City of Santa Clarita Drought Committee. Each reviewed information on water production and demand. The Water Committee agreed to cooperate in sharing water resources regardless of contractual or water rights during the emergency. The City committee made recommendations to the City Council and the water purveyors.

**Drought Conditions.** In the event of a continued drought, it is assumed that the SWP Table A deliveries to CLWA would be curtailed, and that a State Drought Water Bank would be formed. In addition, a combination of supplies would be available such as short-term water exchanges, participation in DWR's dry-year water program, deliveries from CLWA's flexible water account in Castaic Lake Reservoir, and local groundwater pumping in accordance with groundwater studies. Reclaimed water availability is also assumed to be available.

**Earthquake or Other Natural Catastrophes.** If a major earthquake were to occur, or if other catastrophic natural events were to occur elsewhere in the state, it could affect the Santa Clarita Valley. Local storage in reservoirs, combined with requests to the public to reduce consumption, would provide an adequate supply for about seven days. Experts agree that at least 72 hours may elapse before outside help is received; during this period and beyond, the pumping capacity of the retail agencies should provide sufficient water.

**Contamination.** No extended problems with water contamination are anticipated, since the quality of local supplies is good, and steps can be readily taken to isolate a contamination problem. As discussed above, the presence of perchlorate found in one area of the Saugus Formation is currently being addressed through the development of a cleanup plan for this Aquifer.

**Stages of Action.** The agencies have agreed on a four-stage rationing plan, when needed. The trigger points for these stages have been established, priorities set and consumption limits established. A public hearing must be called to implement the rationing plan, and various monitoring procedures have been adopted.

Taken together, an updated Water Shortage Contingency Plan for the Santa Clarita Valley is in place, and has been successfully implemented. (UWMP, Ch. 6.0)

## j. Summary Of Water Supplies For Santa Clarita Valley

The reliability of water supplies available to the CLWA service area does not depend on the "Full Delta Fix" and other water supply improvements recommended by the CALFED Program. CLWA and the retail water purveyors in the Santa Clarita Valley continue to pursue and fund their own local water supply programs. Recently, local water reliability enhancement programs have been undertaken to ensure that the water needs of the service area can be met into the future. As part of this endeavor, numerous programs are being undertaken simultaneously to safeguard against the onset of the next dry year.

As an example, CLWA's long-term Capital Improvement Plan ("CIP") is currently funding the purchase of additional SWP supplies, groundwater storage programs both inside and outside CLWA's service area, surface water storage programs, water conservation and recycling programs, short-term pumping from the Saugus Formation and short-term exchanges from other agencies on an as-needed basis. In 2001 and 2002, CLWA took several specific actions to enhance, preserve and strengthen the quality and reliability of existing and future water supplies in the Santa Clarita Valley. Those actions included, among others, completing the preliminary design for expansion of the Earl Schmidt Filtration Plant from 25 mgd to 56 mgd; obtaining permission from DHS to increase filter flow at the Filtration Plant; negotiating a transfer of 8,786 AFY of 2001 Castaic Creek Flood Flows to CLWA for treatment and use; negotiating with DWR an extended carry-over program for 2001 SWP allocations; signing the Memorandum of Understanding Regarding Urban Water Conservation in California; working to complete acquisition of an additional 16,000 AFY of SWP Table A Amount, following appropriate environmental review, which is underway; and entering into an agreement to bank water in the Semitropic Water Storage District on an interim





basis. These measures implemented over time provide the assurance that alternative supplies will be available in the CLWA service area to meet local water demands well into the future. For long-term planning purposes, water supplies and facilities are added on an incremental basis and in advance of need.

At the same time, however, CLWA, the four local retail water purveyors and other purveyors in the state readily acknowledge that it would be economically imprudent now, or in the short-term, to acquire all of the water supplies and facilities needed for the next twenty-five to thirty years. This type of an approach would represent an unfair shift of costs from future customers in new developments to existing customers in existing developments. In fact, water agencies in California are generally prohibited by law from imposing fees and charges for water supplies and facilities unless those fees and charges are reasonably related to actual services provided.

### (1) Availability of Local Supplies

As shown in Table 4.8-13, projected total future supplies from local groundwater and reclaimed water sources range from 85, 000 AFY in a dry year to 63,000 AFY in an average/normal year.

**Table 4.8-13**
**Planned Local Supplies**
**(acre-feet per year)**

| Source | Average/Normal Year | Dry-Year |
|---|---|---|
| Groundwater | | |
| Alluvial Aquifer | 35,000 | 35,000 |
| Saugus Formation | 11,000 | 13,000 |
| Saugus Formation (new wells)* | -- | 20,000 |
| Reclaimed Water | 17,000 | 17,000 |
| **Total Local Supplies** | 63,000 | 85,000 |

*Source: Santa Clarita Valley Water Report 2002, April 2003 and SB 610 Water Supply Assessment for the Riverpark Project, which are attached to this analysis in Appendix 4.8.*

* *Planned program for future implementation. According to the CLWA, prior to implementing increases in production from groundwater supplies, CLWA will analyze the feasibility, cost and potential water quality and environmental effects of such a program. However, preliminary analyses and recent studies have concluded that additional pumping can be carried out.*

### (2) Availability of Imported Supplies

As shown below in Table 4.8-14, projected supplies from the SWP, water banking/conjunctive-use projects, and water transfers range from 61,273 AFY in average/normal years to 122,540 to 141,390 AFY in dry years.

**Table 4.8-14**
**Planned Imported Supplies**
**(acre-feet per year)**

| Source | Average/Normal Year | Dry Years |
|---|---|---|
| SWP Supplies * | 56,073 | 19,040 - 37,890 |
| Banking/Conjunctive Use** | -- | 100,000 |
| Water Transfers | 5,200 | 3,500 |
| Total Imported Supplies | 61,273 | 122,540-141,390 |

*Source: The State Water Project Delivery Reliability Report, May 2003 and SB 610 Water Supply Assessment for the Riverpark Project, which are attached to this analysis in Appendix 4.8.*
** 56,800 acre-feet = 59.7 percent of maximum Table A Amount; 19,040 acre-feet = 20 percent of maximum Table A Amount; and 37,890 acre-feet = 39.8 percent of maximum Table A Amount.*
*** Planned programs for future implementation pursuant to UWMP 2000, Table 2-5 and SB 610 Water Supply Assessment for the Riverpark Project.*

### (3) Total Water Supply Availability

As shown below in Table 4.8-15, for long-term planning purposes, total water supplies available to the CLWA service area range from 182,240 to 241,790 AFY in dry years, and from 103,200 to 157,100 AFY in average/normal years. For critical dry years, when the reliability of the SWP can be reduced to 20 percent of SWP maximum Table A Amount, CLWA would utilize dry year supplies available from the Saugus Aquifer, and water banking and conjunctive use projects as indicated in Table 4.8-15.

**Table 4.8-15**
**Total Supplies**
**(acre-feet per year)**

| Source | Average/Normal Year | Dry Year |
|---|---|---|
| Local Supplies Groundwater | | |
| Alluvial Aquifer | 35,000 | 35,000 |
| Saugus Formation | 11,000 | 13,000 |
| Saugus Formation (new wells)* | -- | 20,000 |
| Reclaimed Water* | 17,000 | 17,000 |
| Imported Supplies | | |
| SWP Supplies | 56,073 | 19,040 -37,890 |
| Water Banking/Conjunctive Use* | -- | 100,000 |
| Water Transfers* | 5,200 | 3,500 |
| Total Supplies | 124,273 | 207,540 to 226,390 |

*Source: The State Water Project Delivery Reliability Report, May 2003 and SB 610 Water Supply Assessment for the Riverpark Project, which are attached to this analysis in Appendix 4.8.*
** Planned programs for future implementation pursuant to the UWMP 2000, Table 2-6 and SB 610 Water Supply Assessment for the Riverpark Project.*

The remaining portion of this section summarizes "water demand" in the Santa Clarita Valley.





## k. Water Demand In The Santa Clarita Valley

This section describes the historic, existing and projected water use (demand) within the CLWA service area.

CLWA provided historic and existing water usage in the Santa Clarita Valley and the methodology used to forecast future water demand for the valley. Water usage consists of residential, commercial, industrial, recreational, agriculture and other uses. Existing land-use data, new housing construction information and population data were also compiled for the Santa Clarita Valley. The information was then compared to historic trends in water service connections and customer water usage to determine the reasonableness of the projected information. In addition, the CLWA considered the effects of weather and conservation on historic water usage.

This section summarizes the historical and existing water demand in the Santa Clarita Valley and forecasts the water demand in the Valley through 2020.

### (1) Historical And Existing Water Demand In Santa Clarita Valley

The historical and existing water usage was based upon service connections from the four retail water purveyors in the CLWA service area. As shown in Table 4.8-16, the total number of new service connections has increased from 39,299 in 1990 to 58,221 in 2002. This increase in the number of service connections represents slightly more than 500 per year in 1991, to a maximum of 4,200 in 2001, representing an average annual increase of 1,456 new service connections per year.

**Table 4.8-16**
**Historical Number of Service Connections**

| Service Connections | 1990 | 1992 | 1994 | 1996 | 1998 | 2000 | 2002 |
|---|---|---|---|---|---|---|---|
| Valencia Water Co. | 14,272 | 14,854 | 15,703 | 17,420 | 19,863 | 22,000 | 25,286 |
| Newhall | 5,854 | 6,144 | 6,294 | 6,477 | 6,585 | 7,200 | 7,700 |
| Santa Clarita Water Division of CLWA | 18,550 | 19,000 | 19,400 | 19,650 | 20,300 | 22,000 | 24,175 |
| LA County #36 | 623 | 736 | 752 | 768 | 774 | 700 | 1,060 |
| Total | 39,299 | 40,734 | 42,149 | 44,315 | 47,522 | 51,900 | 58,221 |

*Source: CLWA 2000; Santa Clarita Valley Water Report 2000 and 2002.*

### (2) Projected DMS Water Demand In Santa Clarita Valley (2015)

The DMS is an important regulatory component of the County's General Plan. The DMS acts as an early warning system to County decision-makers by providing information about the existing capacity of certain infrastructure, facilities and public services at the time a new development is considered in the four major "urban expansion areas" of the County's General Plan, including the Santa Clarita Valley. The goal of DMS is to identify the new infrastructure, facilities and public services that will be required for new development, and to ensure that the appropriate costs of expanding such infrastructure, facilities and services will be paid for by new development and not assumed by taxpayers in existing developments.

In accomplishing the goals stated above, the DMS determines the availability of certain infrastructure, facilities and services, including water services, on an individual and cumulative basis. The DMS utilizes a computer database that incorporates information supplied by service providers and determines capital facility capacity and demand placed on the system by existing, pending, approved and recorded projects for which land divisions have been filed within the four major "urban expansion areas" of the County's General Plan, including Santa Clarita Valley. The DMS is used to quantitatively determine project and cumulative impacts on certain essential infrastructure, facilities and services, including water service. In EIRs prepared for the County, whenever a proposed project would result in an exceedance of applicable infrastructure, facilities or services, a significant impact is identified and recommended mitigation measures are provided.

The "DMS Build-Out Scenario" entails buildout of subdivision projects listed in the County's Development Monitoring System (DMS), plus the Riverpark project. A DMS analysis is required by the County's General Plan for the cumulative analysis of certain utilities and services, including water service.

The County's DMS database includes all pending, recorded and approved projects for which land divisions have been filed within County unincorporated lands and within the City of Santa Clarita. The City plus County unincorporated area together constitute the County's Santa Clarita Valley Planning Area. A list of the future DMS development activity in the Santa Clarita Valley Planning Area is presented below in **Table 4.8-17**. The listing presented in **Table 4.8-17** does not include General Plan Amendment requests such as the Newhall Ranch Specific Plan. (General Plan Amendment requests are considered in the Santa Clarita Valley Cumulative Build-Out Scenario, which is considered more comprehensive than the DMS Build-Out Scenario. The Santa Clarita Valley Cumulative Build-Out Scenario is discussed in the section below).





**Table 4.8-17**
**Cumulative Development Activity - DMS Build-Out Scenario - Santa Clarita Valley Planning Area**

| Land Use Types | Pending Projects[a] | Approved Projects[b] | Recorded Projects[c] | Total |
|---|---|---|---|---|
| Single-Family Units (detached) | 7,142 du | 8,109 du | 8,385 du | 23,636 du |
| Multi-Family Units | 1,965 du | 8,371 du | 2,868 du | 13,204 du |
| Mobile Homes | 650 du | | | 650 du |
| Commercial | 305 ac | 107 ac | 60 ac | 472 ac |
| Industrial | 195 ac | 188 ac | 200 ac | 583 ac |

*Source: The County of Los Angeles Service Provider Report, Santa Clarita Valley Water Service Purveyors, April 23, 2003.*
*[a] Pending Projects: The County of Los Angeles and City of Santa Clarita subdivisions filed with the County of Los Angeles Department of Regional Planning, which are not yet recorded or expired.*
*[b] Approved: subdivisions approved by the County, which are not yet recorded or expired.*
*[c] Recorded: subdivisions recorded, but not yet built.*
*du = dwelling units*
*ac = acres*

Table 4.8-18 illustrates cumulative water demand for the Santa Clarita Valley service area under the DMS Build-Out Scenario.

**Table 4.8-18**
**Scenario 1: DMS Build-Out Scenario Demand for the Santa Clarita Valley - 2015 (acre-feet per year)**

| | Average Year | Dry Year[a] |
|---|---|---|
| **Santa Clarita Valley DMS Demand** | | |
| - Existing Plus DMS Demand | 97,862 | 107,648 |
| Existing Demand | 61,403 | 61,403 |
| Pending Demand | 7,045 | 7,045 |
| Approved Demand | 9,372 | 9,372 |
| Recorded Demand | 5,984 | 5,984 |
| Other Demand (including Agriculture)[b] | 7,100 | 7,100 |
| Newhall Ranch Specific Plan[c] | 6,958 | 6,958 |
| Dry Year 10% Increase in Demand | 0 | 9,786 |
| - Riverpark Demand | 697 | 697 |
| Dry Year 10% Increase in Demand | 0 | 70 |
| - Less Conservation | (9,856) | (10,842) |
| Total[a] | 88,703 | 97,573 |

*[a] Demand is increased by approximately 10 percent in dry years.*
*[b] This demand figure reflects a reduction in agricultural demand that would occur as the projects shown in the County's DMS are built. According to the Valencia Water Company (DiPrinio, Personal Communication, 2003) water demand in a critical dry year can be expected to decrease by approximately 20 percent through implementation of future water conservation practices in the CLWA service area. This analysis conservatively assumes a 10 percent reduction in critical dry year demand below dry year demand.*
*[c] The Newhall Ranch Specific Plan would only be partially built-out by 2015. It is assumed that development on the Specific Plan site would start to be occupied in 2005 and would be fully built out by 2030. This figure represents 10 years worth of development on the Specific Plan site.*

Without the Riverpark project, future DMS water demand plus existing urban and other demand (including reduced agricultural demand) would be in the total amount of approximately 97,862 AFY (including partial buildout of the Newhall Ranch Specific Plan by 2015 which has been added to the

demands shown in the DMS for the purpose of this analysis). With the water demand of the Riverpark project added (697 AFY in an average year and 767 AFY in a single dry year) and taking into consideration expected water conservation (9,856 AFY in an average year and 10,842 AFY in a dry year), total cumulative demand under the DMS Build-Out Scenario would be approximately 88,703 and 97,573 acre-feet of water per year in an average and dry year, respectively. While no one can precisely predict the year buildout of all projects listed in the DMS would occur, this analysis estimates that DMS buildout would likely occur over the next 10 to 11 years. This analysis assumes that all projects on the DMS buildout in 2015.

**(3) Projected Water Demand In Santa Clarita Valley Up To 2025**

In order to forecast future water demand through 2025, CLWA utilized both the extrapolation method (based on service connections) and the econometric method (based on land-use analysis) as the most accurate means of forecasting water demand through 2025. This combined forecast took the projected growth in new service connections, accounted for the effects of housing trends, land-use changes, development trends, weather and conservation effects to create an estimated increase in water demand through 2025.

**Normal/Average Year Water Demand:** Table 4.8-19 depicts the projected average/normal year water demand for the Santa Clarita Valley through 2020.

**Table 4.8-19**
**Projected Normal/Average Year Water Demand**
**(acre-feet per year)**

| | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Urban Uses | 66,600 | 77,700 | 90,900 | 106,000 |
| Agricultural Uses[1] | 15,100 | 12,400 | 9,800 | 7,100 |
| **Total Projected Demand[2]** | **81,700** | **90,100** | **100,700** | **113,100** |

*Source: Water Supply Assessment for the Riverpark Project, Santa Clarita Water Division of the Castaic Lake Water Agency, August 7, 2003.*

1 *Agricultural water usage is expected to decrease from 17,800 AFY in 1999 to about 7,100 AFY by 2020 due to increased development in the Santa Clarita Valley. This decrease in agricultural demand includes the approximately 7,038 AFY of Newhall Land and Farming Company agricultural water that would be used to partially meet the potable water demands of the Newhall Ranch Specific Plan as Newhall Land and Farming Company's agricultural lands in Los Angeles County are converted to urban uses.*

2 *Does not include expected long-term water conservation savings of 10 percent.*

Using a straight-line projection, water demand is expected to increase to 123,570 AFY by 2025.





**Single Dry Year Water Demand:** CLWA evaluated the estimated dry-year demands and projected supplies for the year 2010 for the purpose of assessing a single dry year. This year was selected in order to show the results of local and imported water supply development over the next 10 years. In May 2003 DWR finalized its State Water Project Delivery Reliability Report. For the worst-case scenario single critical dry year (1977, with a one in 73 year probability of occurrence), DWR estimates that SWP deliveries to contractors would be approximately 20 percent of contract Table A Amounts. Single dry year demand in 2010 is estimated at 81,810 AFY (i.e., 90,900 acre-feet less 9,090 acre-feet (10 percent) to account for expected voluntary conservation).

**Multiple Dry Year Water Assessment:** CLWA estimated the minimum water supply available during each of the three water years, 2001, 2002, and 2003.[30] The surface and groundwater supplies included in this analysis are reflective of supplies available during the 1987-92 drought years, and in particular, 1990, 1991, and 1992. The supplies available from recycling projects are assumed to experience no reduction in a dry year but are also assumed not to be fully on-line at this early stage of the 20-year projection. Demand reductions of 10 percent based on short-term water conservation programs are assumed for these dry-year scenarios (this level of conservation was achieved during the 1987-1992 drought). If projected imported and local supplies are developed as indicated, no shortages are anticipated within the Agency's service area in the dry-year scenarios analyzed.[31] Years 1, 2 and 3 in Table 4.8-20 represent demand projections for 2003 through 2005. The single and multiple dry year water supply and demand assessments from the UWMP are summarized in the following table.[32]

**Table 4.8-20**
**Projected Dry Year and Multi-Dry Year Demand**
**acre-feet per year**

| | Single Dry Year | Multiple Dry Years: Year 1 | Year 2 | Year 3 |
|---|---|---|---|---|
| Total Estimated Demand | 90,900 | 82,000 | 83,300 | 84,600 |
| Voluntary 10% Conservation | 9,090 | 8,200 | 8,330 | 8,460 |
| Total Net Demand | 81,810 | 73,800 | 74,970 | 76,140 |

Information concerning "Future Planned Water Supply Programs" as listed below, from the UWMP and other sources was included to indicate examples of how CLWA would add reliability and flexibility to its

30 UWMP p. 4-3. Hot, dry weather may generate a 10 percent increase above normal in both urban and agricultural water usage. This percentage was used to generate the dry-year demands in Table 2.2.

31 UWMP p. 4-4.

32 Excerpted from Table 4-2 of the UWMP.

water supply portfolio. Programs such as these will be analyzed by CLWA and contracts entered into as need and cost-effectiveness are determined through time. Future Water Supply Assessments will reflect these contractual agreements.

**Long-Term (2025) Dry Year Demand:** To determine the projected water demand in dry years, CLWA relied on studies showing that hot-dry weather may generate a single-year 10 percent increase in both urban and agricultural water usage above and beyond the average/normal year water demand. Therefore, this percentage was used to generate the dry-year demands shown in Table 4.8-21. No conservation savings are reflected in the water demand projections shown in Table 4.8-21. Table 4.8-21 also provides the overall projected water demand for the Santa Clarita Valley through 2020 in average/normal years and dry years.

**Table 4.8-21**
**Projected Dry-Year Water Demand**
**(acre-feet per year)**

| | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Total Projected Normal/Average Year Demand | 81,700 | 90,100 | 100,700 | 113,100 |
| Plus 10% Increase in Usage in Dry-Years | 8,170 | 9,010 | 10,070 | 11,310 |
| Total Projected Dry-Year Demand | 89,870 | 99,110 | 110,770 | 124,410 |

*Source:* CLWA's *SB 610 Water Supply Assessment for the Riverpark Project* and *UWMP 2000, Table 3-5 and Table 4-2.*

Water demand in dry years would increase to 135,927 acre-feet per year by 2025. In considering the future number of service connections needed within the CLWA service area, CLWA utilized the methodology, referred to as the extrapolation method. This method evaluates projected water usage based on the extrapolation of service connections throughout the CLWA service area. Using this method, service connections are exponentially projected for the CLWA service area through 2025. Under this method (exponential projection), the number of new service connections is projected to increase from 49,550 in 1999 to about 96,000 in 2020 and 107,200 in 2025, representing an annual average increase of about 2,240 new connections per year. Recent service connection data is generally consistent with this projected average. Connection data compiled and maintained by CLWA since 2000 shows 2,249 new connections in 2000, 2,822 new connections in 2001, and 2,080 new connections in 2002.[33]

**Figure 4.8-21**, below, depicts the historical and projected number of service connections in the CLWA service area by the year 2020. The figure shows about 96,000 new connections in 2020, with an average

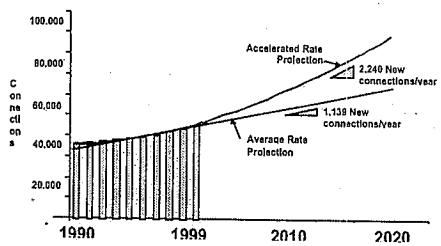
[33] See, CLWA's SB 610 Water Supply Assessment for the Riverpark Project, which is attached to this analysis as **Appendix 4.8.**





annual increase of 2,240 connections per year from 2000 to 2020, using the accelerated rate projection); and it shows about 70,000 new connections in 2020, with an average annual increase of 1,139 connections per year from 2000 to 2020, using an average rate projection).

**Figure 4.8-21**
**Historical and Projected Number of Service Connections**



## 3. RIVERPARK WATER DEMAND AND SUPPLIES

As indicated in the SB 610 Water Supply Assessment for the Riverpark Project an adequate supply of water is available to meet the demands of the Riverpark project without creating significant environmental impacts.

### a. Preface

This section is the "heart" of the Water Services section. This section demonstrates that adequate water sources will be available for buildout of the project by showing that the water purveyor serving the project site has a sufficient supply of water for its customers including those ultimately on the project site.

### b. Water Demand and Delivery

#### (1) Riverpark Water Demand and Delivery

This section presents the water demand for the Riverpark project. In this discussion, the project's water demand is assessed in conjunction with the existing water demand in the Santa Clarita Valley, as well as the future cumulative water demand in the Santa Clarita Valley under near-term and long-term conditions.

The Riverpark project is a proposed residential development consisting of single- and multi-family housing on a 695.4-acre site in the City of Santa Clarita. It includes 439 single-family dwellings, 744 apartments, 40,000 square feet of commercial building area, and a 29-acre passive park, of which a maximum of 8 acres would be landscaped and irrigated. The project site is located at the terminus of Newhall Ranch Road, east of Bouquet Canyon Road between CLWA property and the Santa Clara River, north of Soledad Canyon Road. Home construction is anticipated to begin in 2006 and will continue until buildout in 2009.

Using water demand factors provided by SCWD, the proposed project would consume approximately 697 AFY. The anticipated project demand for water is summarized in Table 4.8-22, Estimated Water Demand, below.





**Table 4.8-22**
**Estimated Water Demand**

| Land Use Category | Amount | Water Duty Factor | Water Demand (AFY) |
|---|---|---|---|
| Single-Family Units | 439 units | 0.55 af/unit | 241.45 |
| Apartments | 744 units | 0.19 af/unit | 141.36 |
| Park | 8 acres | 3 af per acre | 24.0 |
| Other Misc. Landscaping (irrigated common landscaping, pocket parks, etc.) | 93 acres | 3 af per acre | 279.0 |
| Commercial (40,000 sq. ft.) | 3 acres | 0.0289 af/100 sq. ft. | 11.56 |
| TOTAL | | | 697.37 |

**Proposed On-Site Potable Water System:** The proposed project will be served by a series of existing and proposed water lines and water tanks. The proposed project's water delivery system would consist of 16-inch water mains that generally follow the major roadways on and off the project site (i.e., Santa Clarita Parkway and Newhall Ranch Road). Additionally, a system of 8- and 12-inch water lines are proposed to follow the internal roadways of the project. The proposed 16-inch water main in Newhall Ranch Road, to be owned and operated by Santa Clarita Water Company (SCWC), is anticipated to connect to an existing 14-inch SCWC line in Bouquet Canyon Road. This existing line is a Zone A line (Bouquet Zone) (See, **Figure 4.8-22, Proposed On-Site Potable Water System for the location of proposed water zones**). The water storage tank serving the Bouquet Zone is owned and operated by SCWC and is located just north of the project site and is situated at an elevation of 1,450 feet above mean sea level. From this point of connection at Bouquet Canyon Road, the Newhall Ranch Road main will continue east to proposed extension of Valley Center Drive. The main will then follow the alignment of Valley Center Drive to connect to an existing 10-inch line in Soledad Canyon Road (See, **Figure 4.8-22, Proposed On-Site Potable Water System**). This line is within Zone E (Honby Zone) and is fed from a tank three miles east of the project site (also owned and operated by SCWC). This water tank is situated at an elevation of 1,510 feet above mean sea level. A 16-inch water main is also proposed to be located in Santa Clarita Parkway with a connection at Newhall Ranch Road. This line is not proposed to be extended beyond the limits of development by this project. It is currently anticipated that both water production and storage will be accomplished off site at existing SCWC facilities, though the project includes a potential water tank, at one of two possible locations, if needed in the future to serve the project.

**Existing On-Site Water Infrastructure:** Several existing water lines, belonging to Castaic Lake Water Agency (CLWA) and Valencia Water Company (VWC), currently traverse the project site. CLWA's Honby Lateral enters the project site at the eastern boundary. This 33-inch steel pipe continues west across the project site to a point of connection with an 84-inch CLWA water transmission line that exists in the future alignment of Newhall Ranch Road.

Additionally, CLWA is proposing to relocate and upgrade the Honby Lateral within the project site. This realignment and upgrade is part of CLWA's Capital Improvement Program, which was analyzed in a program EIR certified in 1998. CLWA will be preparing a separate project-level environmental document for the relocation and upgrade covering this portion of the Honby Lateral. The Honby Lateral does not provide water service to the Riverpark project.

In addition to the Honby Lateral, CLWA has two existing transmission lines that originate at the agency's water treatment plan north of the Riverpark site. These 84-inch and 102-inch lines travel downhill from the water treatment plant and continue, for the most part, along the currently graded future right-of-way for Newhall Ranch Road to a point of connection with Bouquet Canyon Road. The project proposes no change to these water lines.

VWC operates two water wells on the project site (T-2 and T-4), as well as two wells just off site (U-3 and U-4). There is an existing 12-inch water line that connects well U-4 to T-2. This line then becomes a 16-inch line at well T-2. This 16-inch line traverses the project site in a northwesterly direction until it reaches the currently graded alignment of Newhall Ranch Road. This line continues west and follows the graded roadway alignment. As this line exits the site at the northwestern boundary it ties into 12-inch and 14-inch lines. Valencia Water Company, in conjunction with project development, intends to relocate this line to behind the proposed bank stabilization and within "A" Street to a point of reconnection with the existing VWC line in Newhall Ranch Road. Additionally, VWC will replace the two existing on-site water wells in alternative locations on the project site. Valencia Water Company does not provide water service to the Riverpark project.

**Project Fire Flows:** The Los Angeles County Fire Department requires sufficient capacity for fire flows of 1,250 gallons per minute (gpm) at 20 pounds per square inch (psi) for a two hour duration for single family uses, and up to 5,000 gpm at 20 psi for a duration of up to five hours for multi-family and commercial uses with a first floor area of 35,000 square feet or greater (actual fire flow requirements would be confirmed for each use by the Los Angeles County Fire Department prior to Final Tract Map approval). Based on the experience of the project engineer, PSOMAS, the proposed water system would be able to meet both domestic and fire flow requirements of the project.

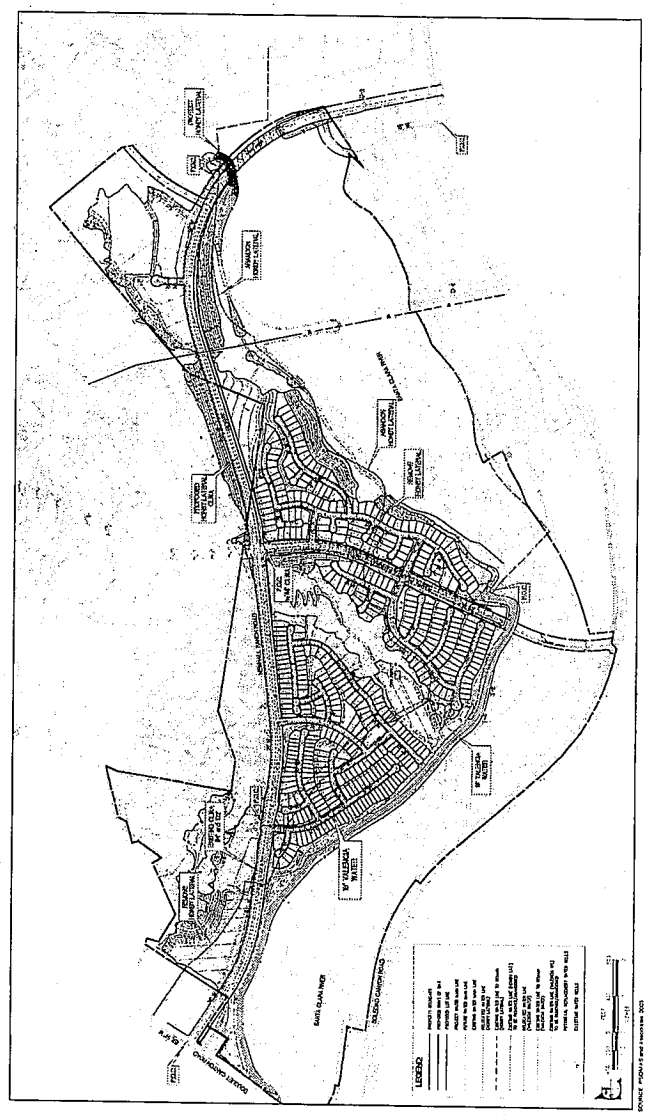



FIGURE 4.8-22
Proposed On-Site Potable Water System

### (2) Existing Conditions Plus Project Water Demand

This section describes the existing development in the Santa Clarita Valley, as well as the project water demand. **Table 4.8-23, Existing Plus Project Demand for the Santa Clarita Valley**, illustrates the project demand, in conjunction with existing demand in the Santa Clarita Valley.

**Table 4.8-23**
**Existing Plus Project Demand for the Santa Clarita Valley**
**(acre-feet per year)**

| | Average Year | Dry Year[b] | Critical Dry Year[c] |
|---|---|---|---|
| Existing Demand[a] | 62,023 | 68,225 | 68,225 |
| Other Demand (Agricultural)[a] | 15,278 | 16,806 | 16,806 |
| Riverpark Demand | 697 | 767 | 767 |
| Critical Dry Year 10% Demand Decrease (Conservation) | | | (8,580) |
| Total Demand | 77,998 | 85,798 | 77,218 |

[a] *Source: Santa Clarita Valley Water Report 2002. Prepared by the Castaic Lake Water Agency, Los Angeles County Waterworks District #36, Newhall County Water District, Valencia Water Company, April 2003.*
[b] *Demand is increased by approximately 10% in dry years. 2002, the year from which this demand was derived, was a dry year and already reflects the 10% increase in demand over a normal or average year. A dry year is a year when below average rainfall occurs after a normal or wet year.*
[c] *Demand in a critical dry year is expected to decrease by as much as 20% due to voluntary and mandatory planned purveyor conservation programs. This analysis assumes a critical dry year 10% reduction in demand from the dry year demand. A critical dry year is a year when rainfall is at a critically low level (i.e., a year that occurs once every 73 years). Such a demand reduction occurred in the last critical dry year experienced in the Santa Clarita Valley (1991).*

As shown, existing water demand in the Santa Clarita Valley is approximately 77,301 AFY in average years (this figure accounts for a dry year increase in water demand in 2002 of approximately 10 percent). Of this demand, approximately 62,023 acre-feet is related to urban or developed areas and approximately 15,278 acre-feet is related to other uses in the Santa Clarita Valley, including agricultural uses. When combined with the Riverpark water demand of 697 AFY, the total water demand in the Santa Clarita Valley would be approximately 77,998 acre-feet if Riverpark were completely built out today. The land use-related water demand would increase by approximately 10 percent in dry years, such as occurred in 2002, resulting in a water demand of approximately 85,798 AFY. In a critical dry year, such as occurred in 1991, demand could decrease by up to 20 percent due to conservation measures that would be enacted by the local water purveyors and CLWA. However, this analysis conservatively assumes that critical dry-year demand would decrease by 10 percent from the dry-year demand. During such extreme conditions, water demand in the Santa Clarita Valley with the Riverpark project would be approximately 77,218 acre-feet.





### (3) Cumulative Water Demand

In order to analyze the cumulative water impacts of Riverpark in combination with other expected future growth, the amount and location of growth expected to occur in addition to that of the project must be predicted. Section 15130(b) of the CEQA Guidelines allows two methods of prediction. The two methods are described as follows: "(a) a list of past, present, and reasonably anticipated future projects producing related or cumulative impacts, including those projects outside the control of the agency; or (b) a summary of projections contained in an adopted general plan or related planning document which is designed to evaluate regional or area-wide conditions." In response to the CEQA requirements, three separate cumulative development scenarios are analyzed for this water analysis in order to meet CEQA requirements as well as the requirements set forth in SB 610 and the County's Development Monitoring System (DMS). The three cumulative scenarios analyzed are referred to below as the "SB 610 Water Supply Assessment Scenario," the "DMS Build-Out Scenario," and the "Santa Clarita Valley Cumulative Build-Out Scenario."

The list of cumulative projects used in this water analysis to assess cumulative impacts is not static. From time to time, the list of cumulative projects is increased or decreased as specific development proposals are applied for, withdrawn, approved, or denied by lead agencies. As part of this analysis, an attempt has been made to be as current as possible; however, it is possible that the list of projects maintained by the City of Santa Clarita or other surrounding jurisdictions will change while this analysis is a subject of public review.

#### (a) SB 610 Water Supply Assessment Scenario - Demands

As indicated previously, a water supply assessment was prepared for the Riverpark project by the Santa Clarita Water Division pursuant to SB 610. The conclusion of the water supply assessment is summarize below and a complete copy of the water supply assessment is attached to this analysis in Appendix 4.8.

Water demands were estimated under three scenarios for the SB 610 Water Supply Assessment. They include the average/normal water year, the single dry year, and multiple dry years. Under the average/normal conditions, water demand in the Santa Clarita Valley would be 81,700 acre-feet in year 2005, 90,100 acre-feet in year 2010, 100,700 acre-feet in year 2015 and 113,100 acre-feet in year 2020.

For the critical dry year (2010), which occurs once every 73 years, water demand in the Santa Clarita Valley would be 90,900 acre-feet less 9,090 acre-feet due to voluntary conservation of 10 percent for a net demand of 81,810 acre-feet (While in the last critical dry year, 1991, a conservation level of 20 percent was

achieved, this portion of the analysis is using a 10 percent reduction in demand is assumed in order to be conservative).

Under the multiple dry-year scenarios and after conservation of 10 percent, Year 1, 2 and 3 demands would be 73,800 acre-feet, 74,970 acre-feet, and 76,140 acre-feet, respectively.

(b) DMS Build-Out Scenario - Demands

The County's DMS database includes all pending, recorded, and approved projects for which land divisions have been filed within County unincorporated lands and within the City of Santa Clarita. The City plus County unincorporated area together constitute the County's Santa Clarita Valley Planning Area. Table 4.8-24 illustrates cumulative water demand for the Santa Clarita Valley service area under the DMS Build-Out Scenario. It should be noted that this scenario also includes a portion of the Newhall Ranch Specific Plan. The Newhall Ranch Specific Plan would only be partially built out by 2015, and it is assumed that development on the Specific Plan site would start to be occupied in 2005 and would be fully built out by 2030. The water demand of Newhall Ranch shown in Table 4.8-24 represents 10 years worth of development on the Specific Plan site.

**Table 4.8-24**
**Scenario 1: DMS Build-Out Scenario Demand for the Santa Clarita Valley - 2015 (acre-feet per year)**

| | Average Years | Dry Years[a] |
|---|---|---|
| **Santa Clarita Valley DMS Demand** | | |
| - Existing Plus DMS Demand | 97,862 | 107,648 |
| Existing Demand | 61,403 | 61,403 |
| Pending Demand | 7,045 | 7,045 |
| Approved Demand | 9,372 | 9,372 |
| Recorded Demand | 5,984 | 5,984 |
| Other Demand (including Agriculture)[b] | 7,100 | 7,100 |
| Newhall Ranch Specific Plan[c] | 6,958 | 6,958 |
| Dry Year 10% Increase in Demand | 0 | 9,786 |
| - Riverpark Demand | 697 | 697 |
| Dry Year 10% Increase in Demand | 0 | 70 |
| - Less Conservation | (9,856) | (10,842) |
| Total[a] | 88,703 | 97,573 |

[a] *Demand is increased by approximately 10 percent in dry years.*
[b] *This demand figure reflects a reduction in agricultural demand that would occur as the projects shown in the County's DMS are built. According to the Valencia Water Company (DiPrinzio, Personal Communication, 2003) water demand in a critical dry year can be expected to decrease by up to 20 percent through implementation of future water conservation practices in the CLWA service area.*
[c] *The Newhall Ranch Specific Plan would only be partially built out by 2015. It is assumed that development on the Specific Plan site would start to be occupied in 2005 and would be fully built out by 2030. This figure represents 10 years worth of development on the Specific Plan site.*





With the water demand of the Riverpark project (697 AFY in an average year and 767 AFY in a single dry year) and taking into consideration expected water conservation (9,856 AFY in an average year and 10,842 AFY in a dry year), total cumulative demand under the DMS Build-Out Scenario would be approximately 88,703 to 97,573 acre-feet of water per year in an average and dry year, respectively.

(c) Santa Clarita Valley 2025 Build-Out Scenario - Demand

CLWA and other retail water purveyors in the Santa Clarita Valley prepared the UWMP, December 2000. CLWA estimated of future water demand for the CLWA service area to the year 2020. The CLWA service area includes the Santa Clarita Valley and a portion of Ventura County. In all, the service area is approximately 192 square miles in size. CLWA and the local retail water purveyors undertook a comprehensive effort to project future water demands and supplies.

CLWA indicates that an extrapolation service connection analysis method produces the most accurate predictions of near-term demand (i.e., 10 to 20 years), but does not account well for economic changes over the long-term (i.e., 50 years). However, the Santa Clarita Valley is not expected to reach buildout by the year 2020. Therefore, another method is needed to estimate the water demand for the Santa Clarita Valley by the year 2025. The year 2025 water demand is included because SB 610 calls for an analysis 20 years into the future. Given that this project would begin construction in approximately 2005 if approved, 2025 was selected for the 20-year analysis.

In order to obtain the most accurate forecast of long-term water demand, CLWA combined the extrapolation/service connection analysis with the econometric/land-use analysis to project the estimated increase in water demand through 2020. Table 4.8-25, below, presents the predicted water demand of the Santa Clarita Valley, including Riverpark and the portion of Newhall Ranch constructed, in the year 2020.

**Table 4.8-25**
**Scenario 3: Santa Clarita Valley 2025 Build-Out Scenario Water Demand**
**(acre-feet per year)**

| | Partial Buildout (year 2020) | | Full Buildout (year 2025) | |
|---|---|---|---|---|
| | Average | Dry | Average | Dry |
| **Build-Out Demand** | | | | |
| - DMS Demand | 88,709 | 88,709 | 88,709 | 88,709 |
| Dry Year 10% Increase in Demand | 0 | 8,871 | 0 | 8,871 |
| - Newhall Ranch Specific Plan [a] | 10,437 | 11,481 | 13,972 | 15,369 |
| - Riverpark Demand | 697 | 697 | 697 | 697 |
| - Additional Urban Demand | 13,257 | 13,186 | 19,798 | 19,663 |
| Dry Year 10% Increase in Demand | 0 | 1,465 | 0 | 2,184 |
| Total | 113,100[c] | 124,410[b] | 123,176[d] | 135,494[b] |

[a] *Newhall Ranch buildout is assumed to occur from 2005 to 2030 at a rate of 864 dwelling units per year, with average water demands of 707 AFY.*
[b] *Demand is increased by approximately 10% in dry years (113,100 x 1.10 = 124,410 and 123,176 x 1.10 = 135,494). Water demand in a critical dry year can be expected to decrease by up to 20% through implementation of water conservation practices in the CLWA service area.*
[c] *Source: UWMP, December 2000, Table 3-5.*
[d] *Source: UWMP, December 2000, Table 3-5, using a straight-line projection from 2020 to 2025.*
*Note: It is expected that the existing plus DMS demand would reach its peak in approximately 2015. The Newhall Ranch Specific Plan demand would begin in approximately 2005 and would reach its peak in approximately 2030. The additional urban demand would begin in approximately 2015, after DMS demand peaks.*

As shown in Table 4.8-25, partial buildout of the Valley by the year 2020 would create an average year water demand of approximately 113,100 AFY. This water demand figure includes the water demand generated by the project and the portion of the Newhall Ranch Specific Plan that would be expected to build out by that time (i.e., a land use water demand of approximately 10,437 AFY). It also includes the water demand of additional urban development that would occur after the buildout of all projects listed in the County's DMS (i.e., approximately 13,257 AFY). In dry years, total demand would increase to approximately 124,410 AFY.

As shown in Table 4.8-25, again using this combined projection method and extrapolating out to 2025, the total water demand in the Santa Clarita Valley by the year 2025, including the project and other development over and above DMS, would be approximately 123,176 AFY in average years and approximately 135,494 AFY in dry years.

### c. Riverpark Water Supplies

This section identifies the water sources that will be available to meet the water demand generated by buildout of the Riverpark project. This section also discusses Riverpark water supplies in conjunction





with existing near-term development and future cumulative long-term development in the Santa Clarita Valley.

As discussed in the above section, the projected total water demand for the Riverpark project is 697 AFY in years with average rainfall (an "average year"). Project water demand increases by approximately 10 percent in years with lower than average rainfall (a single "dry year") to a total of 767 AFY. To meet this demand, water would be provided to the project by the Santa Clarita Water Division (SCWD). The project site is located completely within the SCWD service area. Water sources expected to be used by SCWD include a combination of SWP water delivered through CLWA and local groundwater resources in the Alluvial and Saugus Aquifers. The amount delivered from each source varies year to year due to hydrologic and atmospheric conditions in the state.

#### (1) Existing Conditions Plus Project Water Demand and Supply

This section describes the existing development demand in the Santa Clarita Valley as well as the project water demand, measured against existing supplies. **Table 4.8-26, Existing Plus Project Demand and Supply for the Santa Clarita Valley**, illustrates that existing supplies exceed the project demand, in conjunction with existing demand in the Santa Clarita Valley. Existing water supplies exceed demand by 2,283 to 10,553 AFY in dry years and by 25,775 AFY in an average/normal year after adding the proposed project to existing demands. It should be noted that dry year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand.

Table 4.8-26
Existing Plus Project Demand and Supply for the Santa Clarita Valley
(acre-feet per year)

| | Average Year | Dry Year[b] | Critical Dry Year[c] |
|---|---|---|---|
| Existing Demand[a] | 62,023 | 68,225 | 68,225 |
| Other Demand (agricultural)[a] | 15,278 | 16,806 | 16,806 |
| Riverpark Demand | 697 | 767 | 767 |
| Critical Dry Year 10% Demand Decrease (Conservation) | | | (8,580) |
| Total Demand | 77,998 | 85,798 | 77,218 |
| Existing Water Supply Programs Available: | | | |
| Local Supplies | | | |
| Alluvial Aquifer | 35,000 | 35,000 | 35,000 |
| Saugus Formation | 11,000 | 13,000 | 15,000 |
| Recycled Water | 1,700 | 1,700 | 1,700 |
| Imported Supplies[b] | | | |
| SWP Table A Amount | 56,073 | 37,890 | 19,040 |
| Semitropic Bank Account | | 7,200 | 7,200 |
| Flexible Storage Account | | 1,561 | 1,561 |
| Total Existing Supplies | 103,773 | 96,351 | 79,501 |
| Surplus/(Deficit) | 25,775 | 10,553 | 2,283 |

[a] *Source: Santa Clarita Valley Water Report 2002, Prepared by the Castaic Lake Water Agency, Los Angeles County Waterworks District #36, Newhall County Water District, Valencia Water Company, April 2003.*
[b] *Demand is increased by approximately 10% in dry years. 2002, the year from which this demand was derived, was a dry year and already reflects the 10% increase in demand over a normal or average year. A dry year is a year when below average rainfall occurs after a normal or wet year.*
[c] *Demand in a critical dry year is expected to decrease by as much as 20% due to voluntary and mandatory planned purveyor conservation programs. This analysis assumes a critical dry year 10% reduction in demand from the dry year demand. A critical dry year is a year when rainfall is at a critically low level (i.e., a year that occurs once every 73 years). Such a demand reduction occurred in the last critical dry year experienced in the Santa Clarita Valley (1991).*

## d. Cumulative Water Supply Analysis

The following discussion focuses on the cumulative impacts to water availability for the Santa Clarita Valley. The analysis evaluates cumulative impacts under the following three future water demand and supply scenarios:

- **Scenario 1:** Existing development within the CLWA service area, plus near-term projections, plus the project (referred to as the "SB 610 Water Supply Scenario"); and
- **Scenario 2:** Existing development within the CLWA service area, plus Development Monitoring System ("DMS") projections, plus the project (referred to as the "DMS Build-Out Scenario"); and
- **Scenario 3:** Buildout within the CLWA service area by 2025, plus active pending General Plan Amendment requests, plus the project (referred to as the "Santa Clarita Valley 2025 Build-Out Scenario").





### (1) SB 610 Water Supply Scenario

As indicated previously, a water supply assessment was prepared for the Riverpark project by the Santa Clarita Water Division (SCWD) pursuant to SB 610. A complete copy of the water supply assessment is attached to this analysis in **Appendix 4.8**. In the assessment, SCWD concludes there will be a sufficient water supply available at the time the Riverpark project is ready for occupancy to meet the needs of the project in addition to existing and other planned future uses.

CLWA has existing water allocation rights and contracts to meet future demand as needed over time, and has committed sufficient capital resources and planned investments in various water programs and facilities to serve all of its existing and planned customers, including SCWD's customers. SCWD water rights and contracts for local supplies, in addition to imported supplies provided by CLWA, are sufficient to serve all of its existing and planned customers. SCWD has also identified an operational strategy combined with a prudent and flexible management approach to ensure water reliability.

SCWD's current service area-wide demand is approximately 27,000 AFY.[34] As mentioned previously, the Riverpark project will require 697 AFY at buildout. The conclusions of the SCWD as stated in the 2000 UWMP related to the requirements of the SB 610 for Riverpark are as follows:

**Average/Normal Year Water Assessment.** The UWMP indicates that no shortages are anticipated within the agency's service area in an average/normal water year through 2020 if projected imported and local supplies are developed as estimated.[35] Total projected water demands for the CLWA through the year 2020 are compared with the supplies projected to be available to meet demands in this analysis. The following table, **Table 4.8-27**, summarizes the data from the UWMP.

"Future Planned Water Supply Programs", as listed in **Table 4.8-27**, are included in the UWMP to indicate examples of how CLWA would add reliability and flexibility to its water supply portfolio. Programs such as these will be analyzed by CLWA and contracts entered into as need and cost-effectiveness are determined through time. Future water supply assessments will reflect these contractual agreements.

34 This represents average year demand. Dry year demand is approximately 10 percent higher.
35 Castaic Lake Water Agency, 2000 Urban Water Management Plan (December 2000) p.4-2.

**Table 4.8-27**
**Average/Normal Water Year**
**Supply and Demand Assessment[a]**
**(acre-feet per year)**

| | Year 2005 | Year 2010 | Year 2015 | Year 2020 |
|---|---|---|---|---|
| Existing Water Supply Programs: | | | | |
| Local Supplies | | | | |
| Alluvial Aquifer | 35,000 | 35,000 | 35,000 | 35,000 |
| Saugus Formation | 11,000 | 11,000 | 11,000 | 11,000 |
| Recycled Water | 1,700 | 1,700 | 1,700 | 1,700 |
| Imported Supplies[b] | | | | |
| SWP Table A Amount | 56,073 | 56,073 | 56,073 | 56,073 |
| Total Existing Supplies: | 103,773 | 103,773 | 103,773 | 103,773 |
| Total Estimated Demand | 81,700 | 90,100 | 100,700 | 113,100 |
| Difference - Surplus/(Deficit) | 22,073 | 13,673 | 3,073 | (9,327) |
| Future Planned Water Supply Programs: | | | | |
| Local Supplies | | | | |
| Recycled Water | | 9,000 | 14,000 | 17,000 |
| Imported Supplies | | | | |
| Water Transfers | 5,200 | 5,200 | 5,200 | 5,200 |
| Total Planned Supplies: | 5,200 | 14,200 | 19,200 | 22,200 |
| Net Water Surplus/(Deficit) | 27,273 | 27,873 | 22,273 | 12,873 |

[a] *Excerpted from Table 4-1 of the UWMP.*
[b] *56,800 af represents approximately 59% of CLWA's contractual Table A Amount. Normal year supply based on assumptions from the UWMP. The DWR SWP Delivery Reliability Report 2003 indicates greater reliability of Table A deliveries (72 to 76%) than was assumed for the 2000 UWMP.*

**Single Dry-Year Water Assessment.** The UWMP evaluated the estimated dry-year demands and projected supplies for the year 2010 for the purpose of assessing a single critical dry year. This year was selected in order to show the results of local and imported water supply development over the next 10 years. In May 2003, DWR finalized its State Water Project Delivery Reliability Report. For the worst-case scenario single dry year (1977, with a one in 73 year probability of occurrence), DWR estimates that SWP deliveries to contractors would be approximately 20 percent of contract amounts. If projected imported and local supplies are developed as indicated, no shortages are anticipated within the agency's service area for the extreme-case single dry-year scenario analyzed.[36] In fact, as shown in Table 4.8-27 water supplies exceed demand by 814 acre-feet without considering future planned water supply programs and supplies exceed demand by 81,614 acre-feet with the future programs in the single critical dry year (2010). It should be noted that dry-year supplies available above demand reflect water supplies that would be

36 UWMP p. 4-3. Hot, dry weather may generate a 10 percent increase above normal in both urban and agricultural water usage. This percentage was used to generate the dry-year demands.





*available* to purveyors in dry years. Purveyors would typically secure water from these available supplies only in amounts necessary to meet demand.

**Multiple Dry-Year Water Assessment.** The UWMP estimated the minimum water supply available during each of the three water years, 2001, 2002, and 2003. The surface and groundwater supplies included in this analysis are reflective of supplies available during the 1987-92 drought years, and in particular, 1990, 1991, and 1992. The supplies available from recycling projects are assumed to experience no reduction in a dry year but are also assumed not to be fully on-line at this early stage of the 20-year projection. Demand reductions of 10 percent based on short-term water conservation programs are assumed for these dry-year scenarios (this level of conservation was achieved during the 1987–1992 drought). If projected imported and local supplies are developed as indicated, no shortages are anticipated within the agency's service area in the dry-year scenarios analyzed.[37] Years 1, 2 and 3 in **Table 4.8-28** represent demand projections for 2003 through 2005. The multiple dry-year water supply and demand assessments from the UWMP are summarized in the following table.[38]

Information concerning "Future Planned Water Supply Programs" as listed below from the UWMP and other sources was included to indicate examples of how CLWA would add reliability and flexibility to its water supply portfolio. Programs such as these will be analyzed by CLWA and contracts entered into as need and cost-effectiveness are determined through time. Future Water Supply Assessments will reflect these contractual agreements. As shown, water supplies exceed demand by 9,251 to 11,851 acre-feet without considering future planned water supply programs and supplies exceed demand by 90,051 to 92,651 acre-feet with the future programs in multiple dry years. Again, it should be noted that dry-year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these available supplies only in amounts necessary to meet demand.

37 UWMP, p. 4-4.
38 Excerpted from Table 4-2 of the UWMP.

**Table 4.8-28**
**Dry-Year and Multi-Dry-Year Water Supply and Demand Assessment**
**(acre-feet per year)**

| | Single Dry Year | Multiple Dry Years Year 1 | Year 2 | Year 3 |
|---|---|---|---|---|
| Existing Water Supply Programs | | | | |
| Local Supplies | | | | |
| Alluvial Aquifer | 35,000 | 32,500 | 32,500 | 32,500 |
| Saugus Formation | 13,000 | 13,000 | 13,000 | 13,000 |
| Recycled Water | 1,700 | 1,700 | 1,700 | 1,700 |
| Imported Supplies[a] | | | | |
| SWP Table A Amount | 19,040 | 37,890 | 37,890 | 37,890 |
| Semitropic Bank Account | 7,200 | 7,200 | 7,200 | 7,200 |
| Flexible Storage Account | 4,684 | 1,561 | 1,561 | 1,561 |
| TOTAL EXISTING SUPPLIES | 82,624 | 93,851 | 93,851 | 93,851 |
| TOTAL ESTIMATED DEMANDS | 90,900 | 82,000 | 83,300 | 84,600 |
| Voluntary 10% Conservation | (9,090) | (8,200) | (8,330) | (8,460) |
| Difference - Surplus/(Deficit) | 814 | 11,851 | 10,551 | 9,251 |
| **Future Planned Water Supply Programs** | (2010)[b] | | | |
| Local Supplies | | | | |
| Recycled Water | | 7,300 | | |
| Saugus (New Wells) | | 20,000 | | |
| Imported Supplies | | | | |
| Water Transfers | | 3,500 | | |
| Water Banking/Conjunctive Use | | 50,000 | | |
| TOTAL FUTURE PLANNED SUPPLIES | | 80,800 | | |

[a] *19,040 represents 20% of CLWA's contractual Table A Amount. 37,890 af represents 39.8% of CLWA's contractual Table A Amount. Dry-year supply based on assumptions from the UWMP. The DWR SWP Delivery Reliability Report 2003 indicates greater reliability of Table A deliveries than was assumed for the 2000 UWMP.*

[b] *The UWMP assumed a total of approximately 100,000 af in available future supplies by 2020. Therefore 50,000 af shown herein is assumed to be available by 2010.*

### (2) DMS Build-Out Scenario (2015)

The DMS Build-Out Scenario entails existing development, buildout of the near-term subdivision projects listed in the County's DMS, plus a portion of the Newhall Ranch Specific Plan, plus the project. The analysis of this cumulative development scenario is required by the City for the cumulative analysis of water service. The County's DMS lists all pending, recorded and approved projects for which land divisions have been filed within County unincorporated lands and within the City of Santa Clarita. The City plus County unincorporated areas together constitute the County's Santa Clarita Valley Planning area.





Table 4.8-29, below, illustrates both the cumulative water demand (existing plus DMS) and supply for the Santa Clarita Valley. This cumulative water demand is compared to the near-term projected Santa Clarita Valley water supplies and the additional Newhall Ranch Specific Plan water supplies. As shown, there is an adequate supply of water expected in both average years and dry years and no cumulative water supply impacts would occur. In fact, the table shows that water supplies exceed demand for the DMS Development Scenario by 11,435 to 38,972 acre-feet in average years and by 7,120 to 78,657 acre-feet in a single dry year. However, it should be noted that dry-year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand.

#### (a) DMS General Plan Consistency

The purpose of this subsection is to assess the Riverpark project's consistency with the County's General Plan DMS policies as they relate to water supply. As indicated previously in this section, the County's General Plan includes provisions known as the DMS to give decision makers information about the existing capacity of available public services at the time a new development proposal is considered in the four major Urban Expansion Areas of the County of Los Angeles General Plan (Antelope Valley, Santa Clarita Valley, Malibu/Santa Monica Mountains, and East San Gabriel Valley).[39] The goal of DMS is to identify what new public facilities will be required for the new development, and to ensure that the appropriate cost of any expansion of facilities will be paid for by that new development, and not assumed by the taxpayers.

In accomplishing the goal stated above, the DMS determines the availability of school, fire, sewerage, library, water and road services and facilities on an individual and cumulative basis. The DMS data used for this analysis includes:

(a) Inventory information reports for water, sewer and library services in the Santa Clarita Valley;

(b) Service Provider Reports for the water wholesaler (Castaic Lake Water Agency) and water retailers in Santa Clarita Valley and County Sanitation Districts Nos. 26 and 32; and

(c) A list of all pending, approved and recorded projects where land divisions have been filed within both the unincorporated area of the County and the City of Santa Clarita.

The DMS also works toward ensuring that the expansion costs of new development are paid for by that development.

39 Resolution of the County of Los Angeles Board of Supervisors, Plan Amendment Case No. S.P. 86-173.

To ensure new development is located in close proximity to services and existing development, DMS states that in no event is the proposed development to be located beyond one mile of an existing development or service. Also, DMS states that new development is to be located within, generally, five miles of commercial services and job opportunities.

**Table 4.8-29**
**Scenario 1: DMS Build-Out Scenario Demand and Supply for the Santa Clarita Valley**
**(acre-feet per year)**

| | Average Years | | Dry Years | |
|---|---|---|---|---|
| **Santa Clarita Valley Demand** | | | | |
| - Existing Plus DMS Demand [a] | 97,862 | | 107,648 | |
| - Riverpark Demand | 697 | | 767 | |
| - Less Conservation | (9,856) | | (10,842) | |
| **Total** | 88,703 | | 97,573 | |
| **Santa Clarita Valley Supply [b]** | | | | |
| - Local Supply | | | | |
| a. Groundwater | | | | |
| Alluvial Aquifer | 30,000 to 40,000 | | 30,000 to 35,000 | |
| Less Newhall Ranch Agricultural Water | (3,402) | | (4,534) | |
| Saugus Aquifer | 7,500 to 15,000 | | 11,000 to 15,000 | |
| Saugus Aquifer (new) | 0 | 0 | 10,000 to 20,000 | |
| Newhall Ranch Agricultural Water | 3,402 | | 4,534 | |
| b. Reclaimed Water | 1,700 | 10,737 | 1,700 | 10,737 |
| Less CLWA Reclaimed Water Supply for Newhall Ranch | (1,017) | | (1,017) | |
| Newhall Ranch WRP Supply | 2,103 | | 2,103 | |
| CLWA Newhall Ranch Supply | 1,017 | | 1,017 | |
| - Imported Supplies | | | | |
| a. SWP Supplies [c] | 56,800 | | 37,900 | |
| b. Water Banking/Conjunctive Use | | | 10,000 to 52,500 | |
| c. Desalination | 2,000 to 3,000 | | 2,000 to 3,000 | |
| **Total Supplies** | **100,138 to 127,675** | | **104,693 to 176,230** | |
| **Total Supplies above Demand** | **11,435 to 38,972 [d]** | | **7,120 to 78,657 [e]** | |

[a] *Complete buildout of DMS land uses is estimated to occur in 2015.*
[b] *Source: UWMP, December 2000, Tables 2-6 and 4-1, and the Water Supply Assessment for the Riverpark Project, August 2003, SCWD of CLWA.*
[c] *Consistent with the DWRSIM model, the figures show SWP allocation reduced in average years to approximately 59.7 percent of maximum allocation and in multiple dry years to approximately 39 percent of maximum allocation. The CALSIM II model projects that reliability in average years rises to approximately 75 percent and decreases to 20 percent in a single dry year. In any given year, the actual amount of SWP water deliveries could be above or below these model projections. Deliveries of water associated with the agency's SWP maximum allocation of 95,200 AFY are affected by a number of factors, including hydrologic conditions, the status of SWP facilities' construction, environmental requirements and evolving policies for the Bay-Delta. Programs are in place that have the potential to improve the reliability of imported water. As these programs are needed in dry years, they could be used up to the amounts indicated (as needed).*
[d] *The surplus shown above is the net water available for injection into banking programs (e.g., Semitropic Groundwater Banking Project, other groundwater banking projects, etc.).*
[e] *Dry-year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these available supplies only in amounts necessary to meet demand.*

The DMS includes a computerized database that incorporates information supplied by service providers and determines capital facility capacity and demand placed on the system by existing, pending, approved





and recorded projects for which land divisions have been filed within the four major Urban Expansion Areas. The DMS is used to quantitatively determine project and cumulative impacts on many County and other public services. In EIRs, wherever a proposed development project would result in an exceedance of applicable County infrastructure or facilities (such as water supply), a significant impact is identified and mitigation is recommended as appropriate. The General Plan DMS requirements apply to "subdivisions" proposed within the Santa Clarita Valley.

This analysis addresses water supply requirements resulting from buildout of all pending, recorded, and approved projects listed in the County's DMS, plus the Riverpark project and a portion of the Newhall Ranch Specific Plan. As indicated in Table 4.8-29, **Scenario 1: DMS Build-Out Scenario Demand and Supply for the Santa Clarita Valley**, under the DMS analysis there is sufficient water supply for the entire demand of the Riverpark project and all pending approved and recorded projects in DMS. In fact, available water supplies would exceed demand by 11,435 to 38,972 AFY in an average year and supplies would exceed demand by 7,120 to 78,657 AFY in a dry year (dry-year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand). Therefore, the Riverpark project is not expected to create any significant cumulative water availability impacts.

In addition to ensuring that an adequate supply of water is available for a project, DMS requirements also indicate that the project in question must be located within one mile of an existing development or service and that the development be located within generally five miles of commercial services and job opportunities. The Riverpark site is located immediately adjacent to existing development and is within the retail water service area of the Santa Clarita Water Division of CLWA. It is also within the wholesale service area of the Castaic Lake Water Agency.

Based on the information provided in this analysis, the Riverpark project is consistent with the General Plan DMS policies as they relate to water supplies.

**(3) Santa Clarita Valley 2025 Build-Out Scenario**

The Santa Clarita Valley 2025 Build-Out Scenario entails buildout of lands under the current land-use designations indicated in the County's Area Plan and the City of Santa Clarita's General Plan by the year 2025, plus the proposed Riverpark project, plus all known active pending General Plan Amendment requests for additional urban development in the County unincorporated area and the City of Santa Clarita.

**Table 4.8-30, Scenario 2: Santa Clarita Valley 2025 Build-Out Scenario Water Supplies, and Table 4.8-31, Scenario 2: Santa Clarita Valley 2025 Build-Out Scenario Water Demand and Supply,** summarize the cumulative water demand and supply for this build-out scenario. As shown, at partial buildout by the year 2020, there are adequate water supplies for the project. As a result, the Riverpark project is not expected to create any significant cumulative water availability impacts in either average/normal or dry years. In addition, as shown, at buildout by the year 2025, there are adequate water supplies for the project, with no significant cumulative water supply impacts occurring in either average/normal or dry years. In fact, the two tables show that water supplies exceed demand under this scenario in average and dry years in both 2020 and 2025.

Dry-year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand. For a critical dry year, when reliability of the SWP could be reduced, CLWA would utilize both dry-year supplies available from the Saugus Aquifer, and water banking and conjunctive use projects as indicated in **Table 4.8-30**, which follows.

As depicted in **Table 4.8-30**, purveyors have access to an amount of water supplies that exceed demand during dry conditions. Therefore, no cumulatively significant water availability impacts would occur due to buildout of the Riverpark project.

**(4) Conclusion – Cumulative Impacts**

Because cumulative water supplies exceed demand, cumulative development (including the proposed Riverpark project) would not result in unavoidable significant cumulative impacts on Santa Clarita Valley water resources. This includes potential impacts to groundwater resources related to recharge potential. Based on the memorandum prepared by CH2Mhill entitled Effect of Urbanization on Aquifer Recharge in the Santa Clarita Valley (February 22, 2004; see **Appendix 4.8**), development of the proposed project site and other sites proposed for development in the Santa Clarita Valley, no significant project-specific or cumulative impacts would occur to the groundwater basin with respect to aquifer recharge. This is due to the fact that urbanization in the Santa Clarita Valley has been accompanied by long-term stability in pumping and groundwater levels, plus the addition of imported SWP water to the Valley, which together have not reduced recharge to groundwater, nor depleted the amount of groundwater that is in storage within the Valley. Therefore, cumulative mitigation measures are not required with respect to water resources.





**Table 4.8-30**
**Scenario 2: Santa Clarita Valley 2025 Build-Out Scenario Water Supplies**
**(acre-feet per year)**

| | Buildout (year 2020) | | Buildout (year 2025) | |
|---|---|---|---|---|
| | Average Years | Dry Years | Average Years | Dry Years |
| **Santa Clarita Valley Water Supplies** [a] | | | | |
| **Local Supply** | | | | |
| a. Groundwater | | | | |
| Alluvial Aquifer | 35,000 | 32,500 | 35,000 | 32,500 |
| Saugus Aquifer | 11,000 | 13,000 | 11,000 | 13,000 |
| Saugus Aquifer (new wells) | 0 | 20,000 | 0 | 20,000 |
| b. Reclaimed Water | 17,000 | 17,000 | 17,000 | 17,000 |
| Newhall Ranch WRP Supply | 3,155 | 3,155 | 5,258 | 5,258 |
| **Imported Supplies** | | | | |
| a. CLWA SWP Table A Water [b] | 56,073 | 37,890 | 56,073 | 37,890 |
| Newhall Nickel Water | | | 1,468 | 1,607 |
| Newhall Semitropic Groundwater Storage | | | | 712 |
| b. Water Banking/Conjunctive Use | 0 | 100,000 | 0 | 100,000 |
| Water Transfers | 5,200 | 3,500 | 5,200 | 3,500 |
| **Total Supply** | 127,428 | 227,045 | 131,199 | 219,767 |

[a] *Source: UWMP, December 2000, Tables 2-2, 2-6 and 4-1.*
[b] *SWP maximum allocation reduced in average years to approximately 59.7% of maximum allocation and in dry years to approximately 39.8% of maximum allocation. In any given year, the actual amount of SWP water deliveries could be above or below these model projections.*

**Table 4.8-31**
**Scenario 2: Santa Clarita Valley 2025 Build-Out Scenario Water Demand and Supply**
**(acre-feet per year)**

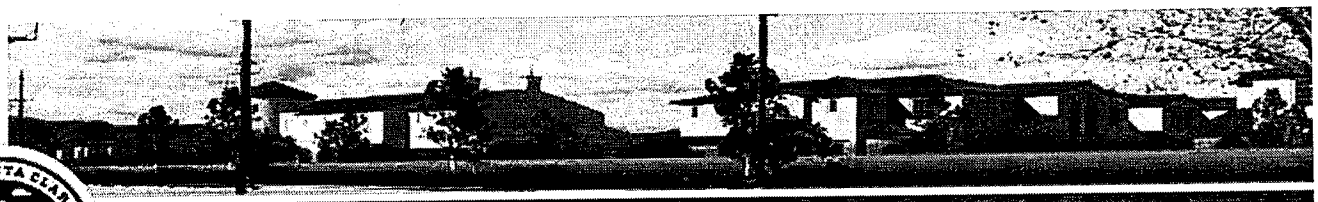
| | Buildout (year 2020) | | Buildout (year 2025) | |
|---|---|---|---|---|
| | Average Years | Dry Years | Average Years | Dry Years |
| Total Build-Out Demand [b] | 113,100[c] | 124,410 | 123,176[c] | 135,494 |
| Santa Clarita Valley Water Supplies [d] | 127,428 | 227,045 | 131,199 | 219,767 |
| Total Surplus [e] | 14,328 | 102,635 | 7,823 | 84,273 |

[a] *Source: 2000 UWMP, December 2000, Table 3-5 and the SB 610 Water Supply Assessment for the Riverpark Project.*
[b] *Demand is increased by approximately 10% in dry years.*
[c] *Source: UWMP, December 2000, Table 3-5, using a straight-line projection from 2020 to 2025.*
[d] *Source: UWMP, December 2000, Tables 2-2, 2-6 and 4-1.*
[e] *Dry-year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these available supplies only in amounts necessary to meet demand.*

Pages omitted.

Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

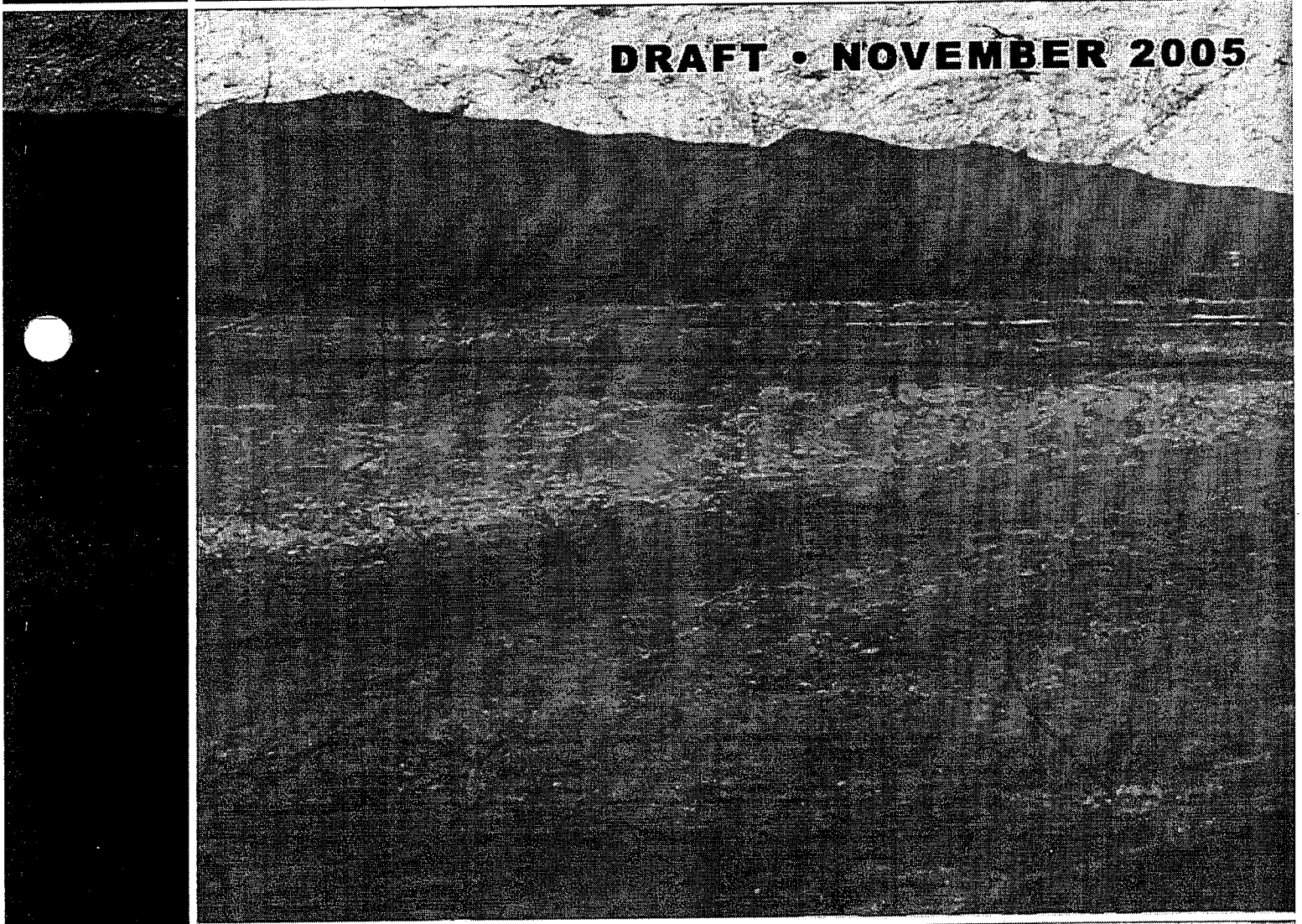
# Attachment 23-B

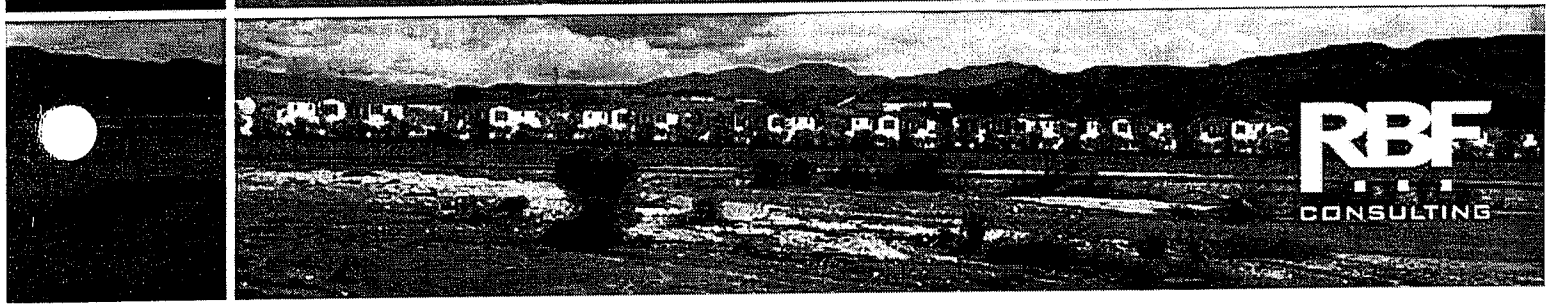


# Soledad Village Environmental Impact Report

SCH NO. 2005041100

**DRAFT • NOVEMBER 2005**





RBF CONSULTING

Pages omitted.

Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

# Section 2.0
# EXECUTIVE SUMMARY

# 2.0 EXECUTIVE SUMMARY

## 2.1 PROJECT LOCATION

The City of Santa Clarita (City) is located 35 miles northwest of downtown Los Angeles between the Interstate 5 (I-5) and State Route 14 (SR-14) freeways, has an area of 47 square miles and a population of 165,000. The City encompasses the communities of Canyon Country, Newhall, Saugus and Valencia. Surrounding the City are various unincorporated areas of Los Angeles County and the Angeles National Forest.

The approximately 30-acre project site is centrally located within the City, along the north side of Soledad Canyon Road adjacent to the Santa Clara River, between Bouquet Canyon Road and Golden Valley Road. The site is triangular shaped with approximately 2,600 feet of frontage along Soledad Canyon Road. A 1,400-foot long by 10-foot wide drainage easement extends along portions of the front of the property parallel to Soledad Canyon Road.

## 2.2 PROJECT OBJECTIVES

The *California Environmental Quality Act* (CEQA) *Guidelines* requires that an environmental impact report (EIR) include a statement of the objectives sought by a project applicant (Section 15123(b) of the *CEQA Guidelines*). The following are the applicant's stated objectives:

**LAND USE PLANNING**

- Create a new community that allows for residential, commercial, and recreational development.
- Provide new housing units to accommodate projected regional growth in a location, which is adjacent to existing and planned infrastructure, urban services, public transit, transportation corridors, and major employment areas.
- Provide development that is compatible with surrounding communities and land uses.
- Provide for the long-term maintenance of public infrastructure and recreational facilities including parks, trails, landscaping, storm drains, etc., that serve the project site.
- To create a small, safe, human scale, residential development enclave, by incorporating traffic calming measures and avoiding the use of long through streets, to foster closer-knit resident interaction, and to reduce and downplay the dominance of the automobile.

## ECONOMIC

- Develop the site to include housing of varying types, accommodating a range of incomes, and commercial opportunities for the residents of the project as well as the local area.
- Provide neighborhood commercial element that would provide retail and services for local residents and area workers.
- Create an economically feasible project.

## MOBILITY

- Provide a safe, efficient, and aesthetically attractive street system, which includes pedestrian walkways (sidewalks) with connection to adjoining regional transportation routes.
- Provide an efficient street circulation system that minimizes impacts on residential neighborhoods and environmentally sensitive areas.
- Takes advantage of the adjacent Metrolink commuter rail station and other transit services.

## PARKS AND RECREATION

- Provide a range of active recreational opportunities, including a recreation center, tot lots, and access to the Santa Clara River Trail and the Soledad Canyon multi-purpose trail.
- Provide passive recreational opportunities such `as pocket park areas and private patios.

## RESOURCE CONSERVATION OBJECTIVES

- To provide a sensitive and protective interface with the Santa Clara River by utilizing appropriate landscape, bank stabilization, and water quality treatments.
- To foster the design and integration of a mutually beneficial relationship between the natural and built environments, sensitive land use transition treatments, attractive street scenes, and indigenous architectural and landscape design guidelines.

# 2.3 PROJECT SUMMARY

The proposed project will develop with residential, commercial, and recreational uses (common and private open space areas) and on-site private roads on approximately 30 acres. The proposed project will require an Amendment to the *City of Santa Clarita General Plan* (*General Plan*) and zone change from Commercial Office (CO) to Residential Medium High (RMH) and Commercial Neighborhood (CN). The proposed project will maintain the Planned Development (PD) zone and Valley Center Concept (VCC Overlay). A Conditional Use Permit (CUP) will also be required, which will implement the Planned Development and allow for an increase of architectural treatment projections from 35 feet, up to 50 feet. Approval of the Tentative Tract Map (TTM No. 62322) is also required to subdivide the Project site for condominium uses, and the applicant is requesting to vacate Finch Court and portions of Gladding Way.

## RESIDENTIAL

A total of 437 residential units will be developed including 275 attached townhomes and 162 triplexes. Two-story triplex units will be developed, with three different floor plans ranging from 1,303 square feet to 1,892 square feet. Two-story townhome units will be developed with four different floor plans ranging from 1,263 square feet to 1,513 square feet. The architectural style will incorporate elements of the California ranch style homes and the Santa Fe and Mediterranean-style houses that are characteristic of the neighboring residential communities. Approximately five percent of the housing will be designated for workforce housing, offering units at approximately 10 percent below market rates.

## COMMERCIAL

An 8,000 square foot retail building will be located at the northeast corner of Gladding Way and Soledad Canyon Road. This will allow for a variety of smaller retail, eatery and service tenants, which is consistent with the CN zone. The architectural elements of the retail building will be consistent with the proposed design of the residential structures. As previously discussed a CUP will need to be approved by the Planning Commission to permit structures over 35 feet in height and up to 50 feet in height. The specific site plan, building elevations, number of parking spaces, landscaping and other improvements for the commercial site will be reviewed separately under the City's Development Review process.

## RECREATIONAL/OPEN SPACE/PEDESTRIAN CIRCULATION

Active Recreational Facilities. A private recreational center will be located north of the commercial building. The facilities will include an approximately 1,200 square foot recreation building (including a community room, restrooms, and a pool equipment room), swimming pool, wading pool, spa, shade structures and a cabana. A private tot lot will also be provided for Soledad Village residents within the eastern portion of the project site. In addition, public pedestrian trails will extend along Soledad Canyon Road, and along the western and southern boundary of the project site along the Santa Clara River. Primary and secondary trails will also be provided throughout the project site. A pedestrian bridge will

also be developed west of the project site. The pedestrian bridge will connect from a trail along the Santa Clara River, cross Soledad Canyon Road to the Metrolink Commuter Rail station.

Passive Recreational Facilities. A total of approximately 2.5 acres of open space will be provided, allowing for passive recreational areas throughout the project site. The project will be buffered from Soledad Canyon Road by a minimum 15-foot wide landscaped setback area. In addition, a sound wall will be constructed along the residential components of the project.

### CIRCULATION/PARKING

Main access to the project site and commercial pad will be provided via Gladding Way off of Soledad Canyon Road. This intersection is already improved with a traffic signal. When entering the project site, Gladding Way will be a four lane divided roadway, which will merge into a two-lane roadway with smaller roadways and driveways extending east and west. Secondary access will be provided via QQ Street, also off of Soledad Canyon Road. Both entrances will include approximately 300-foot right turning pockets (deceleration lanes). A total of 1,094 parking spaces will be provided with 874 covered parking spaces and 220 on-street guest parking spaces. Additional parking spaces will be provided for the commercial site, based on the type of use.

## 2.4 SUMMARY OF PROJECT ALTERNATIVES

In accordance with *CEQA Guidelines* Section 15126.6, Section 6.0, Alternatives, describes a range of reasonable alternatives to the proposed project that could feasibly attain the basic objectives of the proposed project, while evaluating the comparative merits of each alternative. The analysis focuses on alternatives capable of eliminating significant adverse environmental effects or reducing them to less than significant levels, even if these alternatives would impede, to some degree, the attainment of the project objectives. Potential environmental impacts are compared to impacts from the proposed project. The following is a description of each of the alternatives evaluated in Section 6.0, Alternatives.

### NO PROJECT/NO DEVELOPMENT ALTERNATIVE

The No Project/No Development Alternative assumes the Soledad Village Project would not be implemented and land uses and other improvements would not be constructed. The existing project site would remain unaltered and in its current condition. All infrastructure improvements including water, wastewater, drainage, and circulation facilities identified on the Soledad Village Tentative Tract Map would not be constructed, and the project site's *General Plan* and zoning designations would not be changed. No additional entitlements would be required under this Alternative.

### REDUCED DENSITY ALTERNATIVE

The Reduced Density Alternative would be similar to the proposed project in terms of land use types, but would provide multi-family residential units at a lower density. This

Alternative would still require approval of the entitlements required under the proposed project, including the following: Tentative Tract Map, *General Plan* Amendment, zone change, and CUP. The Reduced Density Alternative would retain the 8,000 square feet of commercial retail uses included in the proposed project, but would provide a similar proportion of triplex and townhome dwelling units, but the residential portion of the site would be zoned RM-PD. The RM-PD zone allows for multi-family residential uses at a maximum density of 11 dwelling units per acre (du/acre). Given that the Reduced Density Alternative would still include 8,000 square feet of commercial, a minimum lot size of approximately 1-acre is required for the commercial uses and associated roadways and setbacks under the CN-PD zone, which provides for a maximum floor-area ratio (FAR) of 0.375:1. Per the *Unified Development Code* (*UDC*), a CUP is required for all development within a Planned Development overlay, as well as for architectural elements above the 35-foot maximum building height within the RM and CN zones. As such, the remainder of the project site, approximately 29 acres, would be zoned RM-PD, allowing a density of 319 multi-family dwelling units. As previously indicated, the proportion of housing types in the residential portion of the project under this Alternative is anticipated to be comparable to that of the proposed project, yielding 201 townhome units and 118 triplex units. All other proposed facilities, infrastructure, and amenities would also be provided, to the extent required by the City or other affected agencies.

## EXISTING GENERAL PLAN ALTERNATIVE

The Existing *General Plan* Alternative would eliminate all of the residential uses and dramatically increase the amount of commercial uses on site relative to the proposed project. Under the Existing *General Plan* Alternative, the entire 30-acre project site would remain designated and zoned CO-PD with the VCC overlay. This Alternative would still require approval of a Tentative Tract Map and a CUP, the latter of which is required for all development within a Planned Development overlay. Under this Alternative, no residential units would be constructed on-site, but instead the site would be developed with a mix of office and retail uses. The commercial development would be comprised of approximately 60 percent office uses (980,100 square feet) and 40 percent retail uses (653,400 square feet), totaling 1,633,500 square feet, the maximum allowable density under the CO zone, which limits the FAR to 1.25:1. All other, facilities, parking, landscaping, and infrastructure would also be provided, as required for the CO zone per the UDC.

## WORK-LIVE UNIT ALTERNATIVE

Under the Work-Live Unit Alternative, the proposed project would be modified to provide 22 work-live units in the central portion of the development. These work-live units would be townhome units, which would be intended to provide a convenient, innovative form of workforce housing by allowing homeowners to live and work at home, thereby also reducing vehicle trips. All other aspects of the project under the Work-Live Unit Alternative would be similar to the proposed project, with 412 total residential units (including 222 townhomes, 168 triplex units, and 22 work-live units). In addition, the size of the commercial component will be increased to include 8,000 square feet of first-floor retail uses, and 8,000 square feet of second-floor office.

This Alternative would still require approval of the entitlements required under the proposed project, including the following: Tentative Tract Map, General Plan Amendment, zone change and CUP. The boundaries of the zone change would be modified, as a larger portion of the project site would be zoned CN-PD to allow for the inclusion of work-live units on-site. In addition, the scope of the CUP would be expanded to include the construction of three-story buildings up to 50 feet in height and to include the inclusion of work-live units on-site. In addition, this Alternative would require the approval of a Parking Adjustment, to reduce the parking requirements for the commercial component by 20 percent.

All other proposed facilities, infrastructure, and amenities, including landscaping open space, pathways/trail connections, recreational facilities and pedestrian bridge over Soledad Canyon Road, would still be provided to the extent required by the City or other affected agencies.

## 2.5 SUMMARY OF ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

The summary includes impact statements, level of significance before mitigation, mitigation measures, and level of significance after mitigation.

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| **LAND USE** | | | |
| **Santa Clarita General Plan** | | | |
| The proposed project would be consistent with the applicable goals and policies of the City of Santa Clarita *General Plan.* | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Unified Development Code** | | | |
| The proposed project would not conflict with the standards and requirement of the City of Santa Clarita *Unified Development Code.* | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **SCAG Regional Comprehensive Plan and Guide** | | | |
| The proposed project would not conflict with applicable policies of the Southern California Association of Governments' *Regional Comprehensive Plan and Guide.* | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| **SCAG Southern California Compass Growth Visioning Program** | | | |
| The proposed project would be consistent with the principles and strategies of the Southern California Association of Governments' Southern California *Compass Growth Visioning Program.* | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Cumulative Impacts and Mitigation Measures** | | | |
| Development associated with the proposed project and other related cumulative projects would not result in cumulatively considerable land use and planning impacts. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **POPULATION, EMPLOYMENT, AND HOUSING** | | | |
| **Housing** | | | |
| Project implementation includes the development of a maximum of 437 residential units. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Employment** | | | |
| Project implementation would include development of a maximum of 8,000 square feet of commercial uses. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Population** | | | |
| Project implementation could induce population growth in the City of Santa Clarita. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Cumulative Impacts and Mitigation Measures** | | | |
| Implementation of the proposed project, in conjunction with related projects in the City of Santa Clarita, would not result in significant cumulative population, employment, and housing impacts. | Less than Significant Impact. | No mitigation measures are required. | Not applicable. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| **AESTHETICS** | | | |
| **Short-Term Construction Aesthetic, Light, and Glare Impacts** | | | |
| Development of the proposed project would result in grading and construction activities that would temporarily alter the existing visual character of the project site and the surrounding area and introduce new sources of light and glare. | Potentially Significant Impact. | AES1 Construction equipment staging areas shall be located a minimum of 200 feet from existing residential uses and appropriate screening (i.e., temporary fencing with opaque material), shall be used to buffer views of construction equipment and material, when feasible. Staging location shall be indicated on project Final Development Plans and Grading Plans.<br><br>AES2 All construction-related lighting shall be located and aimed away from adjacent residential areas and consist of the minimal wattage necessary to provide safety at the construction site. A construction safety lighting plan shall be submitted to the City for review concurrent with Grading Permit application. | Less Than Significant Impact. |
| **Long-Term Aesthetic Impacts** | | | |
| Development of the proposed project would alter the existing visual character and viewshed from surrounding locations. | Potentially Significant Impact. | AES3 The site plan, building elevations, number of parking spaces, landscaping and other improvements for the commercial site shall be reviewed in accordance with the City's Development Review process. | Less Than Significant Impact. |
| **Long-Term Light and Glare Impacts** | | | |
| Development of the proposed project would introduce new sources of light and glare into the project area. | Potentially Significant Impact. | AES4 Prior to plan approval, the City of Santa Clarita Planning Division shall ensure that the following elements are included in the project plans, as appropriate:<br><br>◆ A photometric study shall be completed indicating compliance with all lighting standards contained the City's *Unified Development Code* (*UDC*), including, but not limited to Chapter 17.15, *Property Development Standards*, and Chapter 17.19, *Sign Regulations (Private Property)*; | Less Than Significant Impact. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| | | ◆ All exterior lighting shall be designed and located as to avoid intrusive effects on adjacent residential properties and undeveloped areas adjacent to the project site. Low-intensity street lighting and low-intensity exterior lighting shall be used throughout the development to the extent feasible. Lighting fixtures shall use shielding, if necessary to prevent spill lighting on adjacent off-site uses;<br>◆ Design and placement of site lighting shall minimize glare affecting adjacent properties, buildings, and roadways;<br>◆ Fixtures and standards shall conform to state and local safety and illumination requirements;<br>◆ Development projects shall use minimally reflective glass and all other materials used on exterior building and structures shall be selected with attention to minimizing reflective glare; and<br>◆ Automatic timers on lighting shall be designed to maximize personal safety during nighttime use while saving energy. | |
| **Cumulative Impacts and Mitigation Measures** | | | |
| Implementation of the proposed project, in conjunction with related cumulative projects in the City of Santa Clarita, could result in significant cumulative aesthetic, light, and glare impacts. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| **TRAFFIC AND CIRCULATION** | | | |
| **Project Impacts Phase I** | | | |
| Development associated with Phase I of the proposed project could result in adverse impacts to the function of intersections in the project area for short-range traffic conditions. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Project Impacts - Buildout** | | | |
| Development associated with the buildout of the proposed project could result in adverse impacts to the function of intersections in the project area for the interim year (2015) traffic conditions. | Potentially Significant Impact. | TR1 At Project Driveway No. 2 and Soledad Canyon Road, construct a new project intersection with limited access (left-in and right-in, right-out only).<br>TR2 Minimum 300-foot deceleration lanes shall be constructed at both westbound entrances off of Soledad Canyon Road. | Significant and Unavoidable Impact. |
| **Cumulative Impacts and Mitigation Measures** | | | |
| Development associated with the buildout of the proposed project and other related cumulative projects could result in adverse impacts to the function of intersections in the project area for the interim year (2015) traffic conditions. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **AIR QUALITY** | | | |
| **Construction Impacts** | | | |
| Construction activities associated with the proposed project could result in significant air pollutant emissions impacts. | Potentially Significant Impact. | Although construction-related air quality impacts cannot be reduced to less than significant, the following standard air pollution control mitigation measures would serve to reduce impacts to the maximum extent feasible: | Significant and Unavoidable Impact. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| | | AQ1 During construction, the construction contractor shall be responsible for ensuring that all measures listed below in Table 5.5-8, Standard Measures for Construction-Related Emissions, are implemented. To achieve the particulate control efficiencies shown, it is assumed that finished surfaces would be stabilized with water and/or dust palliatives and isolated from traffic flows to prevent emissions of fugitive dust from these areas. In addition, the following water application rates are assumed:<br>◆ Roads traveled by autos, rock trucks, water trucks, fuel trucks, and maintenance trucks: up to twice per hour;<br>◆ Roads traveled by scrapers and loaders in active excavation areas: up to three times per hour;<br>◆ Finish grading areas: up to once every two hours.<br>AQ2 All construction equipment shall be maintained in good operating condition so as to reduce operational emissions. The construction contractor shall ensure that all construction equipment is properly serviced and maintained.<br>AQ3 The construction contractor shall utilize, as much as possible, precoated/natural colored building materials, water-based or low-VOC coating, and coating transfer or spray equipment with high transfer efficiency, such as HVLP spray method, or manual coatings application such as a paintbrush, hand roller, trowel, spatula, dauber, rag, or sponge. | |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| **Long-Term Operational Impacts** | | | |
| Development associated with the proposed project could result in significant air pollutant emissions impacts. | Potentially Significant Impact. | Although no mitigation measures are required to reduce stationary source impacts to less than significant, the following standard measures are recommended for project design to minimize air quality impacts:<br>AQ4 Project design shall incorporate energy-saving features throughout the project, including low-emission water heaters, central water heating systems, and built-in energy efficient appliances.<br>AQ5 Parking areas shall be planted with trees to insure shading and prevent heat buildup. | Significant and Unavoidable Impact. |
| **Air Quality Management Plan Consistency** | | | |
| Development associated the proposed project would result in conflicts with the SCAQMD's adopted air quality management plan. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Cumulative Impacts and Mitigation Measures** | | | |
| Development associated with the proposed project and other related projects could result in cumulatively considerable air quality impacts. | Potentially Significant Impact. | No mitigation measures are required. | Significant and Unavoidable Impact. |
| **NOISE** | | | |
| **Construction-Related Noise** | | | |
| Project-related grading and construction activities could result in temporary noise impacts on nearby noise-sensitive receptors. | Potentially Significant Impact. | N1 Construction shall be limited to the hours of 7:00 AM to 7:00 PM, Monday through Friday, and 8:00 AM to 6:00 PM on Saturday, in accordance with the City of Santa Clarita's Noise Control Ordinance. No construction activities shall be permitted outside of these hours or on Sundays and Federal holidays. | Less Than Significant Impact. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| | | N2 During all site excavation and grading, the project contractor(s) shall equip all construction equipment, fixed or mobile, with properly operating and maintained mufflers consistent with manufacturers' standards.<br><br>N3 The project contractor(s) shall place all stationary construction equipment a minimum of 200 feet from any residential unit, so that emitted noise is directed away from sensitive receptors nearest the project site.<br><br>N4 The project contractor(s) shall locate equipment staging a minimum of 200 feet from any residential unit during all project construction. | |
| **Short-Range Operational Traffic Noise** | | | |
| Development associated with Phase I of the proposed project could permanently increase traffic-related noise in the project area. | Potentially Significant Impact. | <u>Outdoor Active Use Areas</u><br><br>The following mitigation measures would be required for outdoor active use areas associated with residential uses:<br><br>N5 A sound barrier with a minimum wall height of six feet shall be required for ground-floor front-line outdoor active use areas associated with the all dwelling units located directly adjacent to Soledad Canyon Road.<br><br>N6 Balconies or decks, if proposed for front-line dwelling units located directly adjacent to Soledad Canyon Road, shall require a noise barrier with a minimum height of five feet along the perimeter of balconies or decks (balconies or decks on the side of the building facing away from the street or outside of the 65-dBA CNEL impact zone shall not require sound wall protection). | Less Than Significant Impact. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| | | Interior Noise Sound Wall<br>To meet the City's 45-dBA CNEL interior noise standard, the following mitigation measures would be required:<br>N7 Mechanical ventilation, such as an air-conditioning system, shall be required for all dwelling units along the project's southern boundary adjacent to Soledad Canyon Road to ensure that windows can remain closed for prolonged periods of time.<br>N8 Windows with STC-30 or higher shall be required for bedrooms of the dwelling units located adjacent to Soledad Canyon Road west of Gladding Way where no retaining walls are proposed between residential structures and the Soledad Canyon Road right-of-way.<br>N9 Windows with STC-32 or higher shall be required for bedrooms of dwelling units adjacent to Soledad Canyon Road east of Gladding Way.<br>N10 Mechanical ventilation, such as an air-conditioning system, shall be required for the commercial uses proposed on the project site. | |
| **Interim Year (2015) Operational Traffic Noise** | | | |
| Development associated with buildout of the proposed project could permanently increase traffic-related noise in the project area. | Potentially Significant Impact. | Refer to Mitigation Measures N1 through N10. No additional mitigation would be required. | Less Than Significant Impact. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| **Stationary Source Noise** | | | |
| Development associated with the proposed project could permanently increase stationary-source noise in the project area. | Potentially Significant Impact. | N11 Prior to sale of any residential units, future homeowners shall be informed via language in the disclosure documents of the presence of the Saugus Speedway facility, the types of events that can potentially occur at the speedway, the expected frequency of their occurrence, and that noise from events at the speedway may be intermittently audible at their properties during daytime, evening, and late night hours. | Significant and Unavoidable Impact. |
| **Metrolink And Freight Train-Related Noise** | | | |
| Railroad-related noise could result in adverse noise impacts on sensitive receptors in the project area. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Cumulative Impacts and Mitigation Measures** | | | |
| Development associated with the proposed project and other related cumulative projects could result in cumulatively considerable noise impacts. | Potentially Significant Impact. | Refer to Mitigation Measures N5 through N11. No additional mitigation measures are required. | Less Than Significant Impact. |
| **HYDROLOGY AND WATER QUALITY** | | | |
| **Hydromodification Impacts** | | | |
| Development associated with the proposed project could result in adverse hydrology and drainage impacts. | Potentially Significant Impact. | *Tables 5.7-4* and *5.7-5* identify the proposed project's SUSMP requirements and corresponding Project Design Features, and treatment control BMPs that would fully mitigate project impacts. No additional mitigation measures are required. | Less Than Significant Impact. |
| **Groundwater Recharge Impacts** | | | |
| Development associated with the proposed project could result in adverse groundwater recharge impacts. | Potentially Significant Impact. | *Table 5.7-4* identifies the proposed project's SUSMP requirements and corresponding Project Design Features that would fully mitigate project impacts. No additional mitigation measures are required. | Less Than Significant Impact. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| **Operational Surface Water Quality Impacts** | | | |
| Operation of development associated with the proposed project could result in adverse surface water quality impacts. | Potentially Significant Impact. | *Tables 5.7-4* and *5.7-5* identify the proposed project's SUSMP requirements and corresponding Project Design Features, and treatment control BMPs that would fully mitigate project impacts. No additional mitigation measures are required. | Less Than Significant Impact. |
| **Construction-Related Surface Water Quality Impacts** | | | |
| Construction activities associated with implementation of the proposed project could result in adverse impacts to surface water quality. | Potentially Significant Impact. | *Tables 5.7-4* and *5.7-5* identify the proposed project's SUSMP requirements and corresponding Project Design Features, and treatment control BMPs that would fully mitigate project impacts. No additional mitigation measures are required. | Less Than Significant Impact. |
| **Groundwater Quality Impacts** | | | |
| Development associated with the proposed project could result in adverse groundwater quality impacts. | Potentially Significant Impact. | *Tables 5.7-4* and *5.7-5* identify the proposed project's SUSMP requirements and corresponding Project Design Features, and treatment control BMPs that would fully mitigate project impacts. No additional mitigation measures are required. | Less Than Significant Impact. |
| **Cumulative Impacts and Mitigation Measures** | | | |
| Development associated with the proposed project and other related cumulative projects would contribute to cumulative hydrology and water quality impacts. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **WATER SUPPLY** | | | |
| **Water Demand and Supply** | | | |
| Development of the Soledad Village project could create demand for water that exceeds available supplies. | Potentially Significant Impact. | WS5 Prior to the issuance of building permits that allow construction, the applicant of the proposed project shall finance the expansion costs of water service extension to the subdivision through the payment of connection fees to the appropriate water agency(ies). | Less Than Significant Impact. |
| **Cumulative Impacts and Mitigation** | | | |
| Development associated with the proposed project and other related projects would increase demand for water supplies. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| **SCHOOLS/EDUCATION** | | | |
| **Saugus Union School District** | | | |
| Development associated with the proposed project would increase student enrollment within the Saugus Union School District. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Hart District** | | | |
| Development associated with the proposed project would increase student enrollment within the Hart District. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **County Development Monitoring System (DMS) Buildout Scenario** | | | |
| Development associated with the proposed project and other related cumulative projects would increase the demand for school facilities within the Saugus and Hart school districts. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Cumulative Buildout Scenario** | | | |
| Development associated with the proposed project and other related cumulative projects would increase the demand for school facilities within the Saugus and Hart School Districts. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **PARKS AND RECREATION** | | | |
| **Neighborhood and Community Parks** | | | |
| Development of the proposed project would increase usage of neighborhood and community parks. | Potentially Significant Impact. | PR1 The project shall comply with the City Ordinance and Quimby Act in providing a minimum of 4.0 acres of parkland either through the dedication of park area, and/or payment of fees in-lieu of the dedicated parkland. | Less than Significant Impact. |
| **Regional Parks** | | | |
| Development of the proposed project would increase usage of regional parks. | Less Than Significant Impact. | No mitigation measures are required. | No applicable. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| **State and Federal Recreation/Forests** | | | |
| Development of the proposed project would increase usage of State and Federal recreation/forests. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **Trails** | | | |
| Development of the proposed project would increase usage of local trails. | Less Than Significant Impact. | No mitigation measures are required. | Beneficial Impact. |
| **Cumulative Impacts and Mitigation Measures** | | | |
| Development associated with the proposed project and related cumulative projects would increase demands for parks and recreational facilities in the Santa Clarita Valley. | Less Than Significant Impact. | No mitigation measures are required. | Not applicable. |
| **SOLID WASTE** | | | |
| **Construction-Related Impacts** | | | |
| Construction of the proposed project would generate solid waste, which would incrementally decrease the capacity and lifespan of landfills. | Potentially Significant Impact. | SW1 The project applicant/individual project applications shall adhere to all source reduction programs for the disposal of construction materials and solid waste, as required by the City of Santa Clarita. Prior to issuance of building permits, a source reduction program shall be prepared and submitted to the Director of Field Services for the project to achieve a minimum 50 percent reduction in waste disposal rates, including green waste and construction debris. | Significant and Unavoidable Impact. |
| **Operation-Related Impacts** | | | |
| Operation of the proposed project would generate solid waste which would incrementally decrease the capacity and lifespan of landfills. | Potentially Significant Impact. | **General**<br>SW2 The location of recycling/ separation areas shall be in close proximity to dumpsters for non-recyclables, elevators, loading docks, and primary internal and external access points. | Significant and Unavoidable Impact. |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| | | SW3 The location of recycling/ separation areas shall not be in conflict with any applicable federal, state or local laws relating to fire, building, access, transportation, circulation, or safety.<br>SW4 The location of recycling/ separation areas shall be convenient for those persons who deposit, collect, and load the recyclable materials.<br>SW5 Recycling containers/bins shall be located so that they do not block access to each other.<br>SW6 Yard waste shall be reduced through the use of drought-tolerant and native vegetation in common area landscaping wherever possible.<br>**Commercial**<br>SW7 For commercial developments and residential buildings having five or more living units, no refuse collection or recycling areas shall be located between a street and the front of a building.<br>SW8 On-site trash compactors shall be installed for non-recyclables in all restaurants/food services areas.<br>**Residential**<br>SW9 If possible, kitchen, garage or garden design shall accommodate trash and recyclable components to assist in the City's recycling efforts.<br>SW10 Property buyers shall receive educational material on the City's waste management efforts. | |

| IMPACTS | LEVEL OF SIGNIFICANCE PRIOR TO MITIGATION | MITIGATION MEASURES | LEVEL OF SIGNIFICANCE AFTER MITIGATION |
|---|---|---|---|
| | | SW11 The applicant shall comply with all applicable state and Los Angeles County regulations and procedures for the use, collection and disposal of solid and hazardous wastes. | |
| **Cumulative Impacts and Mitigation Measures** | | | |
| Development associated with the proposed project and related cumulative projects would increase the demand for landfill disposal capacity. | Potentially Significant Impact. | Refer to Mitigation Measures SW1 through SW11. No additional mitigation measures are required. | Significant and Unavoidable Impact. |

Pages omitted.

Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

# Section 5.8
# WATER

# 5.8 WATER SUPPLY

This section describes the existing water purveyors in the Santa Clarita Valley and their service areas, and summarizes important characteristics applicable to the water service area in the Santa Clarita Valley, which includes the project site. The data found in the section provides an important backdrop to understanding water supplies and demand in the Santa Clarita Valley generally, as well as understanding the Soledad Village project's water demand and supplies. The following list identifies all of the documentation that has been relied upon in the preparation of the Soledad Village Water Study (WSA), prepared by Impact Sciences (October 2005); refer to Appendix H, Water Study.[1]

- *2000 Urban Water Management Plan, 2005 Groundwater Perchlorate Contamination Amendment and Other Amendments*, prepared by Castaic Lake Water Agency (CLWA), January;
- *Impact and Response to Perchlorate Contamination*, prepared by Luhdorff & Scalmanini Consulting Engineers, April 2005;
- *Santa Clarita Valley Water Report 2004*, prepared by Luhdorff and Scalmanini, Consulting Engineers, for CLWA, Los Angeles County Waterworks District #36, Newhall County Water District (NCWD), and VWC, May 2005;
- *Santa Clarita Valley Water Report 2003*, prepared by Luhdorff and Scalmanini, Consulting Engineers, for CLWA, Los Angeles County Waterworks District #36, Santa Clarita Water Division of CLWA, and VWC, May 2004;
- *Santa Clarita Valley Water Report 2002*, prepared by Luhdorff and Scalmanini, Consulting Engineers, for CLWA, Los Angeles County Waterworks District #36, NCWD, and VWC, April 2003;
- *2001 Update Report, Hydrogeologic Conditions in the Alluvial and Saugus Formation Aquifer Systems*, prepared by Richard C. Slade & Associates LLC, July 2002;
- *Capital Improvement Program*, prepared by CLWA, Kennedy-Jenks Consultants, 2003;
- *The Final State Water Project Delivery Reliability Report*, prepared by California Department of Water Resources, 2002;
- *Water Supply Contract Between the DWR and the CLWA*, (plus amendments, including the "Monterey Amendment," 1995, and Amendment No. 18, 1999, the transfer of 41,000 AF of entitlement from Kern County Water Agency [KCWA] to CLWA), 1963;

[1] All the reference materials are located at the City of Santa Clarita Planning and Economic Development Department, located at 23920 Valencia Boulevard, Suite 300, Santa Clarita, California, 91355.

- *2002 Semitropic Groundwater Storage Program and Point of Delivery Agreement Among the DWR, CLWA and KCWA*;
- *2003 Semitropic Groundwater Storage Program*;
- *Water Management Program*, prepared by Valencia Water Company (VWC), 2001;
- *Hydrogeologic Investigation of the Perennial Yield and Artificial Recharge Potential of the Alluvial Sediments in the Santa Clarita Valley of Los Angeles County, California*, prepared by Richard C. Slade & Associates, December 1986;
- *Hydrogeologic Assessment of the Saugus Formation in the Santa Clarita Valley of Los Angeles County, California*, prepared by Richard C. Slade & Associates, February 1988;
- A technical memorandum prepared by Richard C. Slade & Associates, November 16, 2000;
- A letter from Joseph C. Scalmanini, Luhdorff and Scalmanini Consulting Engineers, dated December 15, 2000, regarding review of the groundwater components of the *UWMP*;
- *Assessment of the Hydrogeologic Feasibility of Injection and Recovery of Water in the Saugus Formation, Santa Clarita Valley, California*, prepared by Richard C. Slade & Associates, February 2001, including the Technical Appendix *Hydrogeologic Conditions in the Saugus Formation, Santa Clarita Valley, California*, February 2001;
- *Newhall Ranch ASR Impact Evaluation*, prepared by CH2MHILL, February 2001;
- *Newhall Ranch Updated Water Resources Impact Evaluation*, prepared by CH2MHILL, September 2002; and
- *Well Q2 Report*, prepared by VWC, April 2005.

## 5.8.1 ENVIRONMENTAL SETTING

### WATER SERVICE

#### Castaic Lake Water Agency

Castaic Lake Water Agency (CLWA) is a public agency that serves an area of 195 square miles in Los Angeles and Ventura counties. CLWA is a water wholesaler that provides approximately one-half of the water for Santa Clarita households and businesses. CLWA operates two potable water treatment plants, storage facilities, and over 17 miles of transmission pipelines. CLWA supplements local groundwater supplies with State Water Project (SWP) water from northern California. This water is treated and delivered to the local water retailers. The four retail purveyors served by CLWA are the Valencia Water

Company (VWC), Los Angeles County Water District #36, Newhall County Water District (NCWD) and the Santa Clarita Division of CLWA (SCWD).

CLWA also delivers highly treated recycled water from one of the two water reclamation plants in the Santa Clarita Valley owned by the Sanitation Districts of Los Angeles County, in order to meet non-potable water demands (golf courses and landscape irrigation, etc.).
In 2001, CLWA signed the *Memorandum of Understanding Regarding Urban Water Conservation in California* (MOU) on behalf of the CLWA service area, as recommended in the *Amended 2000 UWMP*. By signing the MOU, CLWA became a member of the California Urban Water Conservation Council (CUWCC) and pledged to implement all cost-effective Best Management Practices (BMPs) for water conservation. CLWA has implemented 13 of the 14 BMPs recommended by CUWCC (one BMP is currently under revision by CUWCC). CLWA has estimated that conservation measures within the service area can reduce total water demands by approximately ten percent.

## WATER SUPPLY

The current water supply for the Santa Clarita Valley is derived from five primary sources:

- Groundwater from the Alluvial Aquifer;
- Groundwater from the Saugus Formation;
- Imported SWP Water;
- Dry Year Groundwater Banking Programs; and
- Recycled Water.

The sources of water supply within CLWA's service area can be characterized as: (1) local supplies consisting of groundwater and recycled water; and (2) imported supplies that are transported via the SWP and consisting of SWP contract amounts and dry year supplies delivered from groundwater banking programs.

Potential future water sources include acquisition of additional imported water supplies, recycled water, desalination, storm water runoff, increased dry year Saugus pumping, and additional SWP reliability projects. Demand side management programs (conservation) is also considered a component of water supply resulting from efforts by CLWA and other retailers to reduce water demands on a long term basis.

### Local Water Supplies

Groundwater

Groundwater is drawn from two aquifer systems within the Santa Clara River Valley East Sub-basin (Basin), one of the several sub-basins identified along the Santa Clara River in Los Angeles and Ventura counties. The Basin is approximately 22 miles long east to west and 13 miles wide. The shallow aquifer system is designated the Alluvial Aquifer and the deeper aquifer is designated the Saugus Formation.

It is estimated that approximately 200,000 acre-feet (AF) of water is in storage in the Alluvial Aquifer and approximately 1.65 million AF of potentially usable groundwater is present from depths of 500 to 2,500 feet in the Saugus Formation. Neither aquifer system is in overdraft at the present time. The Basin has not been adjudicated and has not been identified as overdrafted or projected to be overdrafted by the Department of Water Resources.

Total pumpage from the Alluvial Aquifer in 2004 was approximately 33,800 AF, an increase of approximately 200 AF from 2003. Of the total Alluvial Aquifer pumpage in 2004, 56 percent (approximately 19,000 AF) was for municipal water supply, and the remaining 44 percent was utilized for agricultural and other miscellaneous. Over the previous 20 years, total pumpage from the Alluvial Aquifer has ranged from a low of approximately 20,000 AFY in 1983 to slightly more than 43,000 AFY in 1999. The Allluvial Aquifer has a sustainable yield ranging from 30,000 to 40,000 AFY. The total annual groundwater production from the Alluvial Aquifer (urban and agricultural production) over the last 10 years has averaged approximately 35,000 AFY, approximately 10 percent higher than earlier estimates of the practical or perennial yield. However, there is no evidence of undesirable conditions that might be an indication of aquifer overdraft.

Total pumpage from the Saugus Formation in 2004 was 6,500 AF, an increase of approximately 2,300 AF from 2003. Of the total Saugus Formation pumpage in 2004, most (5,700 AF) was for municipal water supply, and the remainder (800 AF) was for agricultural and other miscellaneous uses. Groundwater pumpage from the Saugus Formation peaked in the early 1990s and the declined steadily; pumpage remained stable, at an average of approximately 4,800 AFY, since 1998. On a long-term average basis since the importation of SWP water, total pumpage from the Saugus Formation has ranged from a low of approximately 3,700 AFY in 1999 to a high of nearly 15,000 AFY in 1991; average pumpage from 1980 to present has been approximately 7,000 AFY. It is estimated that the Saugus Formation has a sustainable operational yield of 7,500 to 15,000 AFY, and that extraction can be increased on an infrequent basis to range from 15,000 to 35,000 AFY, without creating undesirable conditions (overdraft). However, the increase to 35,000 AFY would be temporary and would need to return to, or be reduced below, the historical range of 7,500 to 15,000 AFY once rainfall patterns returned to normal in order to avoid long-term adverse affects to the aquifer.

Recycled Water

Wastewater that has been highly treated and disinfected can be reused for landscape irrigation and other purposes. It is not suitable for use as potable water. In 1993, CLWA completed a *Reclaimed Water System Master Plan* (*Master Plan*), to use recycled water as a reliable water source to meet some non-potable demand within Santa Clarita Valley. The *Master Plan* is being updated, and the amount of recycled water expected to be produced is approximately 17,000 AFY in 2020. CLWA is currently under contract for 1,700 AFY that became available in 2003.

## Imported Supplies

SWP Overview

In 1951, the California legislature authorized construction of a large state water storage and delivery system. Eight years later, in 1959, the legislature authorized the submission for voter approval of a $1.75 billion general obligation bond issue to build the SWP system. The voters approved the measure, which enabled DWR to commence construction of the SWP.

The DWR operates and manages the SWP facilities. The SWP is the largest state-built, multi-purpose water project in the country. The SWP was designed and built to deliver water, control floods, generate power, provide recreational opportunities and enhance fish and wildlife habitats. SWP water supplies are used for both urban and agricultural uses throughout California. The SWP facilities consist of a complex system of dams, reservoirs, power plants, pumping plants, canals and aqueducts to deliver water.

At the inception of the SWP, DWR entered into individual water supply contracts with agricultural and urban water suppliers (SWP contractors) throughout California. The contracts were the method used to fund construction and operation of the SWP facilities for the delivery of water to the SWP contractors. Each such contract sets forth a maximum annual allocation of SWP water, which is stated in Table A to the contract (Table A Amount, or allocation).

There are currently 29 SWP contractors with water supply contracts with DWR. A SWP contractor may annually request that DWR deliver water in the following year in any amount up to the SWP contractor's Table A Amount. The SWP contracts provide that in a year when DWR is unable to deliver the full amount of contractor requests, deliveries to contractors will be reduced so that total deliveries equal total available supply for that year. Some SWP contractors, including CLWA, historically have never requested delivery of their full annual amount because lower growth, other water supplies and water conservation efforts have held their demand below projections. Other SWP contractors historically have ordered their full Table A Amount nearly every year.

Existing long-term SWP water supply contracts called for the annual delivery of 4,103,651 acre-feet of Table A water by 1997 through SWP facilities, gradually increasing to a maximum of 4,172,686 acre-feet by 2020. Actual demand, however, has also not developed as projected, owing to circumstances, which have changed since the long-term contracts were signed in the 1960s. The changes include slower population growth, changes in local land use, local water conservation programs and conjunctive-use programs. The most SWP Table A water delivered to date (2003) in any year was about 3.5 million acre-feet in 2000. The demands for SWP water are expected to increase as the population of California continues to increase.

Monterey Agreement

By 1994, disputes arose among the many agricultural and urban SWP contractors and DWR regarding the availability and distribution of water through SWP facilities. To avoid potential litigation, DWR and agricultural and urban SWP contractors met in Monterey, California to attempt to resolve the ongoing disputes. After negotiations, DWR and the agricultural and urban SWP contractors agreed to a statement of principles, which became known as the "Monterey Agreement."

The Monterey Agreement, signed by DWR and many of the agricultural and urban SWP contractors in 1994, established principles to be incorporated in contract amendments (the Monterrey Amendments) to be offered to the SWP contractors. To date, all but two SWP contractors (Plumas County Flood Control and Water Conservation District and Empire West Side Irrigation District) have accepted the amendments. The amendments have three primary objectives: (i) to increase the reliability of all SWP contractors' water supplies; (ii) to stabilize the rate structure in order to improve the financial viability of the SWP; and (iii) to increase water management flexibility for all SWP contractors.

The Monterey Agreement provided a number of water management tools that have allowed local agencies to maximize their use of available supplies, thus meeting increased demand without construction of new SWP facilities. Most of these tools are environmentally beneficial or neutral. They include the following:

- Water Transfers: SWP contractors can transfer unneeded Table A water to other contractors on a permanent basis. This provides financial relief from SWP charges for the seller and additional water supplies for the buyer.
- Turnback Pool: SWP contractors with unneeded supplies on a short-term basis can turn their water back into a pool for purchase by other contractors.
- Storage Outside Service Area: SWP contractors are permitted to store water outside their service area (for example, in a groundwater banking project) for later use within their service areas.
- Terminal Reservoirs: SWP contractors are permitted to utilize flexible storage in Castaic Lake and Lake Perris to enhance their water supply reliability.
- SWP Allocation: Allocation of available SWP supply is made based on the proportion of each contractors' maximum contractual Table A water, rather than historical use with agricultural SWP contractors being cut first as in the past. This provides additional reliability to agricultural contractors earlier in the year, which improves their planning capability.
- Interruptible Water: Interruptible water (available surplus water) is distributed on an equal basis among SWP contractors rather than to agricultural SWP contractors first.
- Flexibility: Additional flexibility is granted to SWP contractors wishing to increase or decrease the Table A Amounts in their contracts.

- Banking: The Kern Water Bank was transferred to SWP agricultural users for development and use. This transfer has provided agricultural users as well as other local agencies with additional flexibility and water supply reliability.

- Non-Project Water: Use of project facilities for conveyance of non-project water is permitted to assist SWP contractors, which are able to locate additional sources of water.

As stated above, the Monterey Agreement has facilitated water transfers among SWP contractors. These water transfer provisions have resulted in 130,000 acre-feet of agricultural SWP contractors' Table A Amount being available for sale to urban SWP contractors. Agreements already have been executed among contractors to purchase the additional Table A water from the agricultural SWP contractors. Agreements for the additional Table A Amount of SWP water are effective upon execution (DWR Bulletin No. 132-96, August 1997, Ch. 1, p. 5), and, therefore, are considered permanent water reallocations of SWP Table A water. These permanent transfers of SWP Table A Amounts have allowed urban SWP contractors to obtain additional SWP Table A Amounts, thereby increasing their overall deliveries, even in times of drought. The permanent transfers of SWP Table A Amounts have also allowed SWP urban contractors to increase the reliability of their deliveries by having more Table A Amounts available overall.

The DWR now has approximately eight years of experience in implementing the Monterey Agreement and the associated water management tools identified above. The SWP contractors have come to rely on the Monterey Agreement water management tools and other provisions in their planning activities. Some of the results to date include the following:

- Up to 200,000 acre-feet transferred annually in the Turnback Pool program;

- Nearly 114,000 acre-feet transferred in permanent Table A water transfers;

- Nearly 1,000,000 acre-feet stored outside SWP contractors' service areas;

- Utilization of terminal reservoirs' flexible storage; and

- Delivery of up to 200,000 acre-feet annually in Interruptible water (available surplus water).

Monterey Agreement Environmental Review and Litigation

The Monterey Agreement gave rise to potentially significant environmental effects requiring analysis under CEQA. Therefore, a Program EIR was prepared to address the potentially significant environmental effects of implementing the Monterey Agreement. The Final Program EIR was certified in October 1995. The adequacy of the Final EIR was challenged in litigation arising under CEQA. The Sacramento Superior Court upheld the adequacy of the EIR. Before and after the trial court's decision, DWR and the agricultural and urban

SWP contractors who had executed the Monterey Agreement began implementing various amendment provisions, including the completion of permanent transfers of Table A Amounts among agricultural and urban SWP contractors. The trial court's decision was subsequently appealed. On appeal, the petitioners sought a writ to prevent further implementation of the Monterey Agreement during the appeal. However, the appellate court denied the requested writ (DWR Bulletin 132-98, November 1999, Ch. 6, p. 2).

The appellate court reversed the trial court's decision. The appellate court held that the Program EIR for the Monterey Agreement was improperly prepared by the Central Coast Water Agency, as "Lead Agency" under CEQA, rather than by DWR, which should have been the "Lead Agency." The appellate court also found that the EIR did not sufficiently discuss implementation of a "no project" alternative.

The court then concluded that a new EIR must be prepared and certified. Finally, the court held that the trial court improperly dismissed the plaintiffs' challenge to DWR's transfer of title to the Kern Water Bank from DWR to KCWA.

The appellate court then remanded the case to the trial court and directed that the trial court issue a writ of mandate vacating certification of the EIR and retaining jurisdiction until DWR certifies an EIR in accordance with CEQA. The appellate court further directed that the trial court consider whether the Monterey Agreement may continue to be implemented while the new EIR is being prepared. (Planning & Conservation League v. Department of Water Resources (2000) 83 Cal.App.4th 892.)

The appellate court decision invalidated certification of the EIR, but did not set aside, invalidate or otherwise vacate the Monterey Agreement. In addition, no court orders have been issued to "stay" further implementation of the Monterey Agreement.

In March 2001, the parties to the Monterey Agreement litigation commenced confidential mediation discussions in San Francisco. In a "Joint Statement on the Monterey Amendments Litigation," dated July 18, 2002, the parties to the litigation stated that they "have reached a joint agreement on the principles for settling the lawsuit...." The parties also stated that DWR had commenced preparing a new EIR for the Monterey Agreement. In May 2003, the DWR, Central Coast Water Authority, Kern Water Bank Authority and certain SWP contractors entered into a Settlement Agreement (Settlement) with the Planning and Conservation League, Plumas County Flood Control and Water Conservation District, and Citizens Planning Association of Santa Barbara County, Inc. Pursuant to the Settlement, the department agreed to public negotiation of certain amendments to the long term water supply contracts, including contract amendments to transfer Table A Amounts between existing SWP contractors. The settlement also contains an "Acknowledgment and Agreement Regarding Kern-Castaic Transfer" (i.e., the 41,000 acre-foot CLWA/WRMWSD water transfer described under the heading Santa Clarita Valley SWP Supplies, below). The settlement states: "nothing in this Settlement Agreement is intended to predispose the remedies or other actions that may occur in [the] litigation [on the 41,000 acre-foot transfer]." Consequently, the decisions reached in that litigation stand. Refer to Appendix H for the full text of the Settlement and further information regarding the Monterey Agreement and Monterey Amendment.

Santa Clarita Valley SWP Supplies

*CLWA SWP Table A Amount*

Imported water from the SWP has been a supplemental source of supply to the Santa Clarita Valley since 1980. The SWP is contracted (and designed) to deliver approximately 4.2 million acre-feet of water per year to 29 contracting agencies. However, because the SWP has not been fully constructed and cannot, on a regular basis, deliver the entire 4.2 million acre-feet. CLWA is a contracting agency with a current maximum annual SWP Table A Amount of 95,200 AFY, or about 2.3 percent of the total (The CLWA/WRMWSD water transfer of 41,000 AFY has been completed, CLWA has paid approximately $47 million for the additional Table A Amount, the monies have been delivered, the sales price has been financed through CLWA by tax-exempt bonds, and DWR has increased CLWA's SWP maximum Table A Amount to 95,200 AFY because it was a permanent transfer/reallocation of SWP Table A Entitlement between SWP contractors).

Prior to completion of the CLWA/WRMWSD water transfer, the proposed transfer was the subject of environmental review by the water agencies. The agencies selling the 41,000 acre-feet of SWP Table A Amount to CLWA assessed the environmental consequences of the proposed transfer within their service area in a Final EIR, dated June 1998. This EIR was certified in 1998 and has never been the subject of judicial review. As a result, the EIR is conclusively presumed to be valid. (Pub. Res. Code §21167.2)

CLWA also prepared a supplemental Final EIR, which assessed the environmental effects of CLWA's acquisition of the 41,000 acre-feet within its service area. The Board of Directors of CLWA certified the Supplemental Final EIR in March 1999. Thereafter, in April 1999, a lawsuit was brought challenging the adequacy of the EIR under CEQA (Friends of the Santa Clara River, et al. v. Castaic Lake Water Agency, et al., Case No. BS 056954). The trial court ruled in favor of CLWA and upheld the adequacy of the EIR under CEQA.

In October 2000, the plaintiffs filed an appeal. The appellate court reversed the trial court's judgment and ordered CLWA's EIR decertified. However, the appellate court did not order CLWA to void its approval of the water transfer. Instead, the appellate court remanded the matter to the trial court for further proceedings. After a hearing on September 24, 2002, the trial court concluded that CLWA could utilize the 41,000 AFY to which it is entitled. In December 2004, CLWA certified a new EIR addressing the impacts of the water transfer agreement. That document is now the subject of legal challenge.

*Status of CLWA's Acquisition Under the Monterey Agreement*

The CLWA/WRMWSD transfer of SWP Table A Amount was the type of water transfer that fell within the provisions of the Monterey Agreement. As stated above, under the Monterey Agreement, certain SWP agricultural contractors agreed that 130,000 acre-feet of their Table A Amount could be transferred to urban contractors. The CLWA 41,000 acre-feet acquisition was a part of the 130,000 acre-feet of SWP Table A Amount, which has been transferred under the Monterey Agreement.

The Monterey Agreement provides for those transfers by the participating SWP contractors, thus facilitating transfers of Table A Amounts from agricultural to urban SWP contractors. As stated above, the environmental documentation for the Monterey Agreement has been decertified. However, the legal proceedings (Planning and Conservation League v. Department of Water Resources [2000] 83 Ca.App.4th 892 [PCL litigation]) have not invalidated the Monterey Agreement or enjoined either the Monterey Agreement or further implementation of the Monterey Agreement. In addition, the subsequent settlement agreement in the PCL litigation did not invalidate or otherwise enjoin the Monterey Agreement.

Even in the absence of the Monterey Agreement, CLWA's permanent acquisition of an additional 41,000 acre-feet of SWP Table A Amount could occur under existing SWP water supply contract provisions, subject to appropriate environmental review.

Nothing in the existing SWP water supply contracts, or applicable law, prohibit such water transfers with or without the Monterey Agreement. The Monterey Agreement simply provides a specific vehicle for accomplishing transfers of SWP Table A Amounts from agricultural to urban SWP contractors; the amendments under the Monterey Agreement are not the exclusive means by which that amount may be transferred. In support of that fact, in 1981 (almost 15 years before the Monterey Agreement), the entire SWP Table A Amount of the Hacienda Water District was permanently transferred to the Tulare Lake Basin Water Storage District, pursuant to an agreement approved by DWR.

The acquisition of the 41,000 acre-feet could proceed as a water transfer under existing law. See, e.g., Water Code §§382, 383 (authority for transferring surplus water) and Water Code §1745, et seq. (authority for transferring non-surplus water). The KCWA has reaffirmed its willingness to allow transfers of up to 130,000 acre-feet of SWP Table A Amounts under pre-Monterey Agreement conditions even if the Monterey Agreement is ultimately invalidated.

If it were not for existing SWP water supply contract provisions which allow such transfers (without the need for the Monterey Agreement), and existing law which enables CLWA to enter into contracts outside the context of the Monterey Agreement, an adverse final judgment invalidating the Monterey Agreement could affect CLWA's completed acquisition of the 41,000 acre-feet, which could in turn impair CLWA's supply of SWP water through its contracts with DWR and other SWP contractors. However, CLWA believes that an adverse outcome in the Monterey Agreement litigation is not likely to adversely affect CLWA's water supplies over the long term because CLWA believes that such a result is unlikely to "unwind" executed and completed agreements with respect to the permanent transfer of SWP Water Amounts.

In May 2003, the California Department of Water Resources (DWR) completed its *State Water Project Deliver Reliability Report*. This report provides current information on the ability of the SWP to deliver water under existing and future levels of development, assuming historical levels of precipitation. On average, the SWP will be able to deliver between 72 to 76 percent of the maximum total contract amount of 4.1 million AF at both current and projected (2020) levels of demand. Assuming SWP reliability of 76 percent, CLWA's average/normal water year deliveries would be approximately 72,350 AFY. The single critical

dry year deliveries, according to the DWR are forecasted to be approximately 18,088 AFY and the multiple dry year deliveries could be approximately 35,244 AFY.

### Average/Normal Year, Single Dry Year and Multiple Dry Year Water Supply

The amount of water supply available from the various sources is summarized in *Table 5.8-1, Existing Water Supplies (Acre-Feet)*. *Table 5.8-1* is not intended to be an operational plan for how supplies would be used in a particular year, but rather identifies the complete range of water supplies available under a range of hydrologic conditions. Diversity of supply allows SCWD and the purveyors the option of drawing on multiple sources of supply in response to changing conditions such as varying climatic conditions (average/normal years, single dry years, multiple dry years), natural disasters and contamination with substances such as perchlorate.

**Table 5.8-1**
**Existing Water Supplies (Acre-Feet)**

| | Available During | | Available During Single Dry Year | Available During Each of Three Consecutive Dry Years |
|---|---|---|---|---|
| | Average Year | Wet Year | | |
| *Local Supplies* | | | | |
| Alluvial Aquifer | 35,000 | 40,000 | 32,500 | 32,500 |
| Saugus Formation | 11,000 | 11,000 | 15,000 | 24,000 |
| Recycled Water | 1,700 | 1,700 | 1,700 | 1,700 |
| *Imported Supplies* | | | | |
| SWP Amount[1] | 56,800 | 95,200 | 37,900 | 37,900 |
| Draw From Short-term Semitropic Bank Account | 0 | 0 | 50,870 | 16,950 |
| Draw From Flexible Storage Account | 0 | 0 | 4,684 | 1,561 |
| **Existing Supplies (2004)** | **104,500** | **147,900** | **142,654** | **114,611** |

1. Since the *2000 UWMP* was adopted, DWR released its SWP Delivery Reliability Report (May 2003), which analyzes the reliability of SWP supplies. During infrequent dry periods, deliveries are projected to be less than 50 percent, and possibly as low as 19 percent during an unusual single dry year condition that occurs about once every 70 years. During very wet years, full deliveries can be expected. Thus, the amount of water available to CLWA in the worst-case single dry year would be 19 percent of 95,200 AF (18,088 AF). In a worst-case multiple dry-year period, the amount of water available to CLWA in each of those dry years would be 37 percent of 95,200 AF (35,244 AF). The May 2003 DWR report also assumes average year SWP deliveries of 76 percent. This would result in 72,352 AF of CLWA's entitlement amount. The *2005 UWMP* will reflect this new information.

For the *2000 UWMP*, water supplies reflected in this table are based on SWP reliability as of 2000. Use of the 2003 SWP reliability figures would reduce the existing Single Dry Year and Consecutive Dry Year Amounts to 18,088 AF and 35,244 AF, respectively. The corresponding total existing supplies would be reduced to 122,842 AF and 112,955 AF, respectively. Total existing and planned supplies in Single Dry and Consecutive Dry Years would be reduced to 147,272 AF and 134,305 AF, respectively. Assuming 76 percent reliability in the average year, total existing supplies would be 120,052 AF, and total existing and planned supplies would be 135,352 AF.

Source: *Amended 2000 UWMP*.

In April 2005, VWC confirmed the detection of perchlorate in its Well Q2, an Alluvial well, in connection with its regular monitoring of active municipal-supply wells near the former Whittaker-Bermite site. In response, VWC removed the well from active service, and requested Luhdorff & Scalmanini, Consulting Engineers to prepare a report assessing the impact of, and response to, the perchlorate contamination in VWC's Well Q2 (*Q2 Report*).

The *Q2 Report* documents that the perchlorate detected in Well Q2 does not significantly impact the water supplies used to meet demand in the Santa Clarita Valley. VWC's response plan for Well Q2 is to pursue permitting and installation of wellhead treatment by the fall of 2005, which will return the well to water supply service.

**2000 URBAN WATER MANAGEMENT PLAN AND 2005 AMENDMENT**

The final version of the Santa Clarita Valley's Urban Water Management Plan (2000 UWMP) was adopted by the CLWA Board of Directors on December 20, 2000. In the County of Ventura v. Castaic Lake Water Agency case, (Kern County Superior court case no. 245365-RJO), the validity and sufficiency of the regional 2000 UWMP prepared by VWC, CLWA and NCWD were challenged. The Court of Appeal issued a decision that focused on the 2000 UWMP's discussion regarding perchlorate contamination as it related to groundwater supplies and concluded that the 2000 UWMP must have a discussion as to the time needed to implement the method for treating the affected groundwater as well as a discussion as to the reliability of groundwater during the treatment period. The decision also required the trial court to vacate the approval of the 2000 UWMP. However, SCWD and the other affected water agencies have prepared and adopted an amendment to the 2000 UWMP, the Water Management Plan, (Amendment 2000 UWMP) to address the insufficiencies identified by the Court of appeal regarding perchlorate contamination. The CLWA and other retailers are currently preparing the 2005 Water Management Plan, with approval anticipated by the end of 2005. Some supply and demand factors may be modified but the overall conclusions (there is sufficient water for existing and planned growth) are expected to remain the same.

The *Amended 2000 UWMP* uses *Table 5.8-1* as a basis for developing the mix of supplies for the two operational scenarios needed to meet the demand. The near-term and long-term operating scenarios have been conservatively developed to match available supplies necessary to meet existing and projected demands over the next three years and through the year 2020. Because of the diverse nature of these supplies, there are multiple combinations of supplies that can be utilized in any year to meet demands, and the scenarios presented in the *Amended 2000 UWMP* represent reasonable assumptions about the availability of each water supply based upon the most up to date information at this time.

The *Amended 2000 UWMP* concluded the following findings in regards to groundwater supply:

- Both the Allluvial Aquifer and the Saugus Formation are reasonable and sustainable sources at the yields represented in the *Amended 2000 UWMP*;
- The yields are not overstated and will not deplete or "dry up" the groundwater basin; and
- There is no need to reduce the yields for purposes of planning in the context of the *Amended 2000 UWMP*.

Based on the findings in the *Q2 Report* and the *Amended 2000 UWMP*, CLWA, SCWD, and other retail purveyors believe that sufficient water supplies continue to be available to meet the current and projected water demands in the Santa Clarita Valley over the next 20-year horizon, even after taking into account groundwater supply impacted by perchlorate contamination.

## 5.8.2 SIGNIFICANCE THRESHOLD CRITERIA

Appendix G of the *CEQA Guidelines* contains the Initial Study Environmental Checklist form used during preparation of the project Initial Study, which is contained in Appendix A of this EIR. The Initial Study includes questions relating to water. The issues presented in the Initial Study Checklist have been utilized as thresholds of significance in this section. Accordingly, a project may create a significant environmental impact if one or more of the following occurs:

- Have sufficient water supplies available to serve the project from existing entitlements and resources, or require new or expanded entitlements; and
- Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects.

## 5.8.3 IMPACTS AND MITIGATION MEASURES

### WATER DEMAND AND SUPPLY

◆ ***DEVELOPMENT OF THE SOLEDAD VILLAGE PROJECT COULD CREATE DEMAND FOR WATER THAT EXCEEDS AVAILABLE SUPPLIES.***

***Level of Significance Prior to Mitigation***: Potentially Significant Impact.

***Impact Analysis***: The Soledad Village project is a proposed residential development consisting of multi-family housing on a 30-acre site in the City of Santa Clarita. It would include 437 townhomes, 8,000 square feet of commercial building area, and a recreation center.

Using water demand factors provided by Santa Clarita Water Division, the proposed project would consume approximately 154 AFY. The anticipated project demand for water is summarized in *Table 5.8-2, Estimated Water Demand*.

**Table 5.8-2**
**Estimated Water Demand**

| Land Use Category | Amount | Water Duty Factor | Water Demand (AFY) |
|---|---|---|---|
| Townhomes | 437 units | 0.24 AFY per unit | 104.9 |
| Recreation Area | 0.75 | 3 AFY per acre | 2.2 |
| Landscaping | 15 acres | 3 AFY per acre | 45.0 |
| Commercial (8,000 square feet) | 1 acre | 0.0289 AFY per 100 square feet | 2.3 |
| **Total** | | | **154.4** |

## Existing Conditions Plus Project Water Demand

*Table 5.8-3, Existing Plus Project Demand for the Santa Clarita Valley*, illustrates the project demand, in conjunction with existing demand in the Santa Clarita Valley. As shown in *Table 5.8-3*, existing water demand in the Santa Clarita Valley is approximately 82,364 AFY in average years (this figure accounts for a dry year increase in water demand in 2004 of approximately 10 percent). Of this demand, approximately 66,364 AFY is related to urban or developed areas and approximately 16,000 AFY is related to other uses in the Santa Clarita Valley, including agricultural uses. When combined with the Soledad Village project, water demand of 154 AFY, the total water demand in the Santa Clarita Valley would be approximately 82,518 AFY if Soledad Village were completely built out today. The land use-related water demand would increase by approximately 10 percent in dry years, resulting in a water demand of approximately 89,169 AFY. In a critical dry year, demand could decrease by up to 20 percent due to conservation measures that would be enacted by the local water purveyors and CLWA. However, this analysis conservatively assumes that critical dry-year demand would decrease by 10 percent from the dry-year demand. During such extreme conditions, water demand in the Santa Clarita Valley with the Soledad Village project would be approximately 80,252 AF.

*Table 5.8-4, Existing Plus Project Demand and Supply for the Santa Clarita Valley*, illustrates that existing supplies exceed the project demand, in conjunction with existing demand in the Santa Clarita Valley. Existing water supplies exceed demand by 42,590 to 62,485 AFY in dry years and by 21,982 AFY in an average/normal year after adding the proposed project to existing demands. It should be noted that dry year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand.

## Table 5.8-3
## Existing Plus Project Demand for the Santa Clarita Valley

| | Average Year | Dry Year[1] | Critical Dry Year[2] |
|---|---|---|---|
| Existing Demand | 66,364 | 73,000 | 73,000 |
| Other Demand (Agricultural) | 16,000 | 16,000 | 16,000 |
| Soledad Village Demand | 154 | 169 | 169 |
| Critical Dry Year 10% Demand Decrease | | | (8,917) |
| **Total Demand** | **82,518** | **89,169** | **80,252** |

Notes:
1. Demand is increased by approximately 10 percent in dry years. 2004, the year from which this demand was derived, was a dry year and already reflects the 10 percent increase in demand over a normal or average year. A dry year is a year when below average rainfall occurs after a normal or wet year.
2. Demand in a critical dry year is expected to decrease by as much as 20 percent due to voluntary and mandatory planned purveyor conservation programs. This analysis assumes a critical dry year 10 percent reduction in demand from the dry year demand. A critical dry year is a year when rainfall is at a critically low level (i.e., a year that occurs once every 73 years). Such a demand reduction occurred in the last critical dry year experienced in the Santa Clarita Valley (1991).

Source: *Santa Clarita Valley Water Report 2004*, prepared by the CLWA, Los Angeles County Waterworks District #36, Newhall County Water District, VWC, May 2005.

## Table 5.8-4
## Existing Plus Project Demand and Supply for the Santa Clarita Valley

| | Average Year | Dry Year[1] | Critical Dry Year[2] |
|---|---|---|---|
| Existing Demand | 66,364 | 73,000 | 73,000 |
| Other Demand (agricultural) | 16,000 | 16,000 | 16,000 |
| Soledad Village Demand | 154 | 169 | 169 |
| Critical Dry Year 10% Demand Decrease | | | (8,917) |
| **Total Demand** | **82,518** | **89,169** | **80,252** |
| Existing Water Supply Programs Available: | | | |
| Local Supplies | | | |
| Alluvial Aquifer | 35,000 | 32,500 | 32,500 |
| Saugus Formation | 11,000 | 24,000 | 15,000 |
| Recycled Water | 1,700 | 1,700 | 1,700 |
| Imported Supplies[1] | | | |
| SWP Table A Amount | 56,800 | 37,900 | 18,088 |
| Semitropic Bank Account | | 50,870 | 50,870 |
| Flexible Storage Account | | 4,684 | 4,684 |
| **Total Existing Supplies** | **104,500** | **151,654** | **122,842** |
| **Surplus/(Deficit)** | **21,982** | **62,485** | **42,590** |

Notes:
1. Demand is increased by approximately 10 percent in dry years. 2004, the year from which this demand was derived, was a dry year and already reflects the 10 percent increase in demand over a normal or average year. A dry year is a year when below average rainfall occurs after a normal or wet year.
2. Demand in a critical dry year is expected to decrease by as much as 20 percent due to voluntary and mandatory planned purveyor conservation programs. This analysis assumes a critical dry year 10 percent reduction in demand from the dry year demand. A critical dry year is a year when rainfall is at a critically low level (i.e., a year that occurs once every 73 years). Such a demand reduction occurred in the last critical dry year experienced in the Santa Clarita Valley (1991).

Source: *Santa Clarita Valley Water Report 2004*, prepared by the CLWA, Los Angeles County Waterworks District #36, Newhall County Water District, VWC, May 2005.

Table 5.8-5, Example Near-Term Operation Scenario Average/Normal Water Year Water Supply and Demand Assessment, and Table 5.8-6, Example Near-Term Operation Scenario Single Dry Year and Multiple Dry Year Water Supply and Demand Assessment, delineate the mixes of water supplies expected to be used to meet demands in the next three years (2005-2007) under average/normal water supply conditions (refer to Table 5.8-5) and under dry water supply conditions (refer to Table 5.8-6). This three-year period was selected to specifically respond to concerns over the reliability of supply during the implementation phase of the perchlorate contamination treatment project to restore currently impacted groundwater supplies. This scenario takes into account the impact of perchlorate on the reliability of groundwater supplies from the Alluvial aquifer and Saugus Formation under an average/normal year, single dry year, and three consecutive dry years. It also includes delivery of dry year "firming" supplies that were planned but not yet available when the *2000 UWMP* was adopted. The mix of water supplies from available groundwater not impacted by perchlorate contamination in combination with other available supplies is sufficient to meet customer demands with a high degree of reliability over the next three years, which includes the transition to full restoration of groundwater production currently impacted by perchlorate contamination.

**Table 5.8-5**
**Example Near-Term Operation Scenario**
**Average/Normal Water Year Water Supply**
**and Demand Assessment**

| Existing Water Supply | 2005 | 2006 | 2007 |
|---|---|---|---|
| *Local Supplies* | | | |
| Alluvial Aquifer | 35,000 | 35,000 | 35,000 |
| Saugus Formation | 5,000 | 5,000 | 9,000 |
| Recycled Water | 700 | 1,000 | 1,300 |
| *Imported Supplies* | | | |
| SWP Table A Amount | 41,000 | 42,380 | 39,760 |
| Draw From Short-Term Semitropic Bank Acct | 0 | 0 | 0 |
| Draw From Flexible Storage Account | 0 | 0 | 0 |
| **Existing Supply** | **81,700** | **83,380** | **85,060** |
| **Existing Demand** | **81,700** | **83,380** | **85,060** |

Source: *Groundwater Perchlorate Contamination Amendment and Other Amendments, 2000 Urban Water Management Plan*, CLWA, CLWA Santa Clarita Water Division, Newhall County Water District, Valencia Water Company, January 2005.

## WATER DISTRIBUTION SYSTEM

The entire project site is located within Santa Clarita Water Division Pressure Zone E. The project would be served by a proposed looping system of water lines connecting to an existing 10-inch water main located on the north side of Soledad Canyon Road at the east end and to a 14-inch main installed along the remaining project frontage in the south side of Soledad Canyon Road. The proposed project's water delivery system would consist of 12- to 16-inch water mains that generally follow the roadway system within the project site. Additionally, a series of fire hydrants would be located along Soledad Canyon Road.

**Table 5.8-6**
**Example Near-Term Operation Scenario**
**Single Dry Year and Multiple Dry Year Water Supply**
**and Demand Assessment**

| Existing Water Supply | Single Dry Year | Multiple Dry Years | | |
|---|---|---|---|---|
| | 2005 | 2005 | 2006 | 2007 |
| *Local Supplies* | | | | |
| Alluvial Aquifer | 32,500 | 32,500 | 32,500 | 32,500 |
| Saugus Formation | 5,000 | 5,000 | 5,000 | 11,000 |
| Recycled Water | 700 | 700 | 1,000 | 1,300 |
| *Imported Supplies* | | | | |
| SWP Table A Amount | 37,900 | 37,900 | 37,900 | 37,900 |
| Draw From Short-Term Semitropic Bank Acct | 916 | 4,039 | 5,419 | 2,360 |
| Draw From Flexible Storage Account | 4,684 | 1,561 | 1,561 | 0 |
| **Existing Supply** | **81,700** | **81,700** | **83,380** | **85,060** |

Source: *Groundwater Perchlorate Contamination Amendment and Other Amendments, 2000 Urban Water Management Plan,* CLWA, CLWA Santa Clarita Water Division, Newhall County Water District, Valencia Water Company, January 2005.

The Los Angeles County Fire Department requires sufficient capacity for fire flows of 5,000 gallons per minute (gpm) at 20 pounds per square inch (psi) for a five-hour duration for multi-family and commercial uses with a first floor area of 35,000 square feet or greater (actual fire flow requirements would be confirmed for each use by the Los Angeles County Fire Department prior to final tract map approval). According to the project engineer, the proposed water system would be able to meet both domestic and fire flow requirements of the project.

In summary, there would be sufficient water supply to meet the project's water demand under an average/normal water year, single dry year, or multiple dry years. In addition, the proposed project would include development of a distribution system that would provide sufficient capacity for domestic and fire flow requirements. Regardless, mitigation measures are recommended in order to ensure impacts to water supply and distribution remain below a level of significance.

***Mitigation Measures:***

WS1 Landscape concept plans shall include a palette rich in drought-tolerant and native plants.

WS2 Major manufactured slopes shall be landscaped with materials that will eventually naturalize, requiring minimal irrigation.

WS3 Water conservation measures as required by the State of California shall be incorporated into all irrigation systems.

WS4 Prior to commencement of use, all uses of recycled water shall be reviewed and approved by the State of California Health and Welfare Agency, Department of Health Services.

WS5 Prior to the issuance of building permits that allow construction, the applicant of the proposed project shall finance the expansion costs of water service extension to the subdivision through the payment of connection fees to the appropriate water agency(ies).

***Level of Significance After Mitigation:*** Less Than Significant Impact.

## 5.8.4 CUMULATIVE IMPACTS AND MITIGATION MEASURES

◆ ***DEVELOPMENT ASSOCIATED WITH THE PROPOSED PROJECT AND OTHER RELATED PROJECTS WOULD INCREASE DEMAND FOR WATER SUPPLIES.***

***Level of Significance Prior to Mitigation:*** Less Than Significant Impact.

***Impact Analysis***: The following discussion focuses on the cumulative impacts to water availability for the Santa Clarita Valley. The analysis evaluates cumulative impacts under the following three future water demand and supply scenarios:

Scenario 1: Existing development within the CLWA service area, plus near-term projections, plus the project (referred to as the "SB 610 Water Supply Scenario");

Scenario 2: Existing development within the CLWA service area, plus Development Monitoring System ("DMS") projections, plus the project (referred to as the "DMS Build-Out Scenario"); and

Scenario 3: Buildout within the CLWA service area by 2025, plus active pending General Plan Amendment requests, plus the project (referred to as the "Santa Clarita Valley 2025 Build-Out Scenario").

**SB 610 Water Supply Scenario**

As indicated previously, a WSA is not required for the Soledad Village project. However, for information purposes, an SB 610 scenario was prepared. As indicated below, there will be a sufficient water supply available at the time the Soledad Village project is ready for occupancy to meet the needs of the project in addition to existing and other planned future uses.

CLWA has existing water allocation rights and contracts to meet future demand as needed over time, and has committed sufficient capital resources and planned investments in various water programs and facilities to serve all of its existing and planned customers, including Santa Clarita Valley Water Division's customers. Santa Clarita Valley Water Division's water rights and contracts for local supplies, in addition to imported supplies provided by CLWA, are sufficient to serve all of its existing and planned customers. Santa Clarita Valley Water District has also identified an operational strategy combined with a prudent and flexible management approach to ensure water reliability.

Santa Clarita Valley Water District's current service area-wide demand is approximately 29,191 AFY. As mentioned previously, the Soledad Village project will require 154 AFY at buildout. The conclusions as stated in the *2000 UWMP* related to the requirements of the SB 610 for Soledad Village are as follows:

Average/Normal Year Water Assessment: The *UWMP* indicates that no shortages are anticipated within the agency's service area in an average water year through 2020 if planned water supply programs are developed as estimated. Without such programs, a deficit is possible in 2020. Total projected water demands for the CLWA through the year 2020 are compared with the supplies projected to be available to meet demands in this analysis. The following table, *Table 5.8-7, Long-Term Projection Average/Normal Water Year Water Supply and Demand Assessment*, summarizes the data from the *2000 UWMP*.

**Table 5.8-7**
**Long-Term Projection Average/Normal Water Year**
**Water Supply and Demand Assessment**

| | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| **EXISTING WATER SUPPLY** | | | | |
| *Local Supplies* | | | | |
| Alluvial Aquifer | 35,000 | 35,000 | 35,000 | 35,000 |
| Saugus Formation | 5,000 | 11,000 | 11,000 | 11,000 |
| Recycled Water | 700 | 1,700 | 1,700 | 1,700 |
| *Imported Supplies* | | | | |
| SWP Table A Amount | 41,000 | 56,800 | 56,800 | 56,800 |
| Draw From Short-Term Semitropic Bank Account | 0 | 0 | 0 | 0 |
| Draw From Flexible Storage Account | 0 | 0 | 0 | 0 |
| **Total Existing Supply** | **81,700** | **104,500** | **104,500** | **104,500** |
| **PLANNED WATER SUPPLY** | | | | |
| *Local Supplies* | | | | |
| Recycled Water | 0 | 7,300 | 12,300 | 15,300 |
| *Imported Supplies* | | | | |
| Draw From Long-Term Water Banking Programs | 0 | 0 | 0 | 0 |
| Total Planned Supply | 0 | 7,300 | 12,300 | 15,300 |
| **Total Supply (Existing Plus Planned)** | **81,700** | **111,800** | **116,800** | **119,800** |
| **Estimated Demand (without conservation)** | **81,700** | **90,100** | **100,700** | **113,100** |

Source: *Amended 2000 UWMP.*

Single Dry Year Water Assessment: The *2000 UWMP* evaluated the estimated dry-year demands and projected supplies for the year 2010 for the purpose of assessing a single critical dry year. This year was selected in order to show the results of local and imported water supply development over the next 10 years. For the worst-case scenario single dry year (1977, with a one in 73 year probability of occurrence), DWR estimates that SWP deliveries to contractors would be approximately 20 percent of contract amounts. If projected imported and local supplies are developed as indicated, no shortages are anticipated within the agency's service area for the extreme-case single dry-year scenario analyzed.[2] In fact, as

[2] *UWMP* p. 4-3. Hot, dry weather may generate a 10 percent increase above normal in both urban and agricultural water usage. This percentage was used to generate the dry year demands.

shown in *Table 5.8-8, Long-Term Projection Single Dry Year and Multiple Dry Year Water Supply and Demand Assessment*, water supplies exceed demand by 56,484 AF in the single, critical-dry year (2010). It should be noted that dry year supplies available above demand reflect water supplies that would be called upon by purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand.

**Table 5.8-8**
**Long-Term Projection Single Dry Year and Multiple Dry Year Water Supply and Demand Assessment**

| | Single Dry Year 2010 | Multiple Dry Years Year 1 2018 | Year 2 2019 | Year 3 2020 |
|---|---|---|---|---|
| **Existing Water Supply** | | | | |
| *Local Supplies* | | | | |
| Alluvial Aquifer | 32,500 | 32,500 | 32,500 | 32,500 |
| Saugus Formation | 15,000 | 15,000 | 15,000 | 15,000 |
| Recycled Water | 1,700 | 1,700 | 1,700 | 1,700 |
| *Imported Supplies* | | | | |
| SWP Table A Amount[1] | 37,900 | 37,900 | 37,900 | 37,900 |
| Draw From Short-Term Semitropic Bank Account (through 2013) | 17,500 | 0 | 0 | 0 |
| Draw From Flexible Storage Account | 4,684 | 1,561 | 1,561 | 1,561 |
| **Total Existing Supply** | **109,284** | **88,661** | **88,661** | **88,661** |
| **Planned Water Supply** | | | | |
| *Local Supplies* | | | | |
| Restored Contaminated Wells | 10,000 | 10,000 | 10,000 | 10,000 |
| New Saugus Wells | 0 | 0 | 0 | 10,000 |
| Recycled Water | 7,300 | 12,300 | 12,300 | 15,300 |
| *Imported Supplies* | | | | |
| Draw From Long-Term Water Banking Programs | 20,000 | 13,000 | 13,000 | 13,000 |
| **Total Planned Supply** | **37,300** | **35,300** | **35,300** | **48,300** |
| **Total Supply (Existing plus Planned Future)** | **146,584** | **123,961** | **123,961** | **136,961** |
| **Estimated Demand (without conservation)** | **90,100** | **108,140** | **110,620** | **113,100** |

Source: *Amended 2000 UWMP*. Since the *2000 UWMP* was adopted, DWR released its SWP Delivery Reliability Report (May 2003), which analyzes the reliability of SWP supplies. During infrequent dry periods, deliveries are projected to be less than 50 percent, and possible as low as 19 percent during an unusual single dry year condition that occurs about once every 70 years. During very wet years, full deliveries can be expected. Thus, the amount of water available to CLWA in the worst-case single dry year would be 19% of 95,200 AF, or 35,244 AF. The *2005 UWMP* will reflect this new information.

For the *2000 UWMP*, water supplies reflected in this table are based on SWP reliability as of 2000. Use of the 2003 SWP reliability figures would reduce the existing single dry year and consecutive dry year Table A Amounts to 18,088 AF and 35,244 AF, respectively. The corresponding total existing supplies would be reduced to 89,472 AF and 86,005 AF, respectively. Total existing plus planned supplies in single dry, consecutive dry years 1–2 and consecutive dry year 3 would be reduced to 126,772 AF, 121,305 AF and 134,305 AF, respectively.

Multiple Dry Year Water Assessment: The *2000 UWMP* estimated the minimum water supply available during each of the three water years, 2018, 2019, and 2020; refer to *Table 5.8-8*. The surface and groundwater supplies included in this analysis are reflective of supplies available during the 1987 to 1992 drought years, and in particular, 1990, 1991, and 1992. The supplies available from recycling projects are assumed to experience no reduction

in a dry year but are also assumed not to be fully on-line at this early stage of the 20-year projection. Demand reductions of 10 percent based on short-term water conservation programs are assumed for these dry-year scenarios (this level of conservation was achieved during the 1987–1992 drought). If projected imported and local supplies are developed as indicated, no shortages are anticipated within the agency's service area in the dry-year scenarios analyzed.[3] As shown in *Table 5.8-8*, water supplies exceed demand by 13,341 to 23,861 AF in multiple dry years. Again, it should be noted that dry year supplies available above demand reflect water supplies that would be called upon by purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand.

**DMS Build-Out Scenario (2015)**

The County's General Plan includes provisions known as the DMS to give decision makers information about the existing capacity of available public services at the time a new development proposal is considered in the four major Urban Expansion Areas of the County of Los Angeles General Plan (Antelope Valley, Santa Clarita Valley, Malibu/Santa Monica Mountains, and East San Gabriel Valley).[4] The goal of DMS is to identify what new public facilities will be required for the new development, and to ensure that the appropriate cost of any expansion of facilities will be paid for by that new development, and not assumed by the taxpayers. To ensure new development is located in proximity to services and existing development, DMS states that in no event is the proposed development to be located beyond one mile of an existing development or service. Also, DMS states that new development is to be located within, generally, five miles of commercial services and job opportunities. The DMS also works toward ensuring that the expansion costs of new development are paid for by that development.

This analysis addresses water supply requirements resulting from buildout of all pending, recorded, and approved projects listed in the County's DMS, plus the Soledad Village project and a portion of the Newhall Ranch Specific Plan. As indicated in *Table 5.8-9, Scenario 1: DMS Build-Out Scenario Demand and Supply for the Santa Clarita Valley*, under the DMS analysis there is sufficient water supply for the entire demand of the Soledad Village project and all pending, approved, and recorded projects in the DMS. In fact, available water supplies would exceed demand by 15,876 to 24,913 AF in average years and by 45,145 to 82,994 AF in a dry year (dry year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand). Therefore, the Soledad Village project is not expected to create any significant cumulative water availability impacts.

In addition to ensuring that an adequate supply of water is available for a project, DMS requirements also indicate that the project in question must be located within one mile of an existing development or service and that the development be located within generally five miles of commercial services and job opportunities. The Soledad Village site is located immediately adjacent to existing development and is within the retail water service area of

[3] UWMP p. 4-4.

[4] Resolution of the County of Los Angeles Board of Supervisors, Plan Amendment Case No. S.P. 86-173.

the Santa Clarita Water Division of CLWA. It is also within the wholesale service area of the CLWA.

**Table 5.8-9**
**Scenario 1: DMS Build-Out Scenario Demand and Supply for the Santa Clarita Valley**

| | Average Years | Dry Years |
|---|---|---|
| **Santa Clarita Valley Demand** | | |
| Existing Plus DMS Demand[1] | 100,654 | 110,720 |
| Soledad Village Demand | 154 | 169 |
| Less Conservation | (10,081) | (11,089) |
| **Total** | **90,727** | **99,800** |
| **Santa Clarita Valley Supply[2]** | | |
| *Local Supply* | | |
| Groundwater | | |
| Alluvial Aquifer | 35,000 | 32,500 |
| Less Newhall Ranch Agricultural Water | (3,402) | (4,534) |
| Saugus Formation | 11,000 | 15,000–24,000 |
| Restored Impacted Wells | 0 | 10,000 |
| Saugus Formation (new) | 0 | 10,000 |
| Newhall Ranch Agricultural Water | 3,402 | 4,534 |
| Reclaimed Water | 1,700 - 10,737 | 1,700 - 10,737 |
| Less CLWA Reclaimed Water Supply for Newhall Ranch | (1,017) | (1,017) |
| Newhall Ranch WRP Supply | 2,103 | 2,103 |
| CLWA Newhall Ranch Supply | 1,017 | 1,017 |
| *Imported Supplies* | | |
| SWP Supplies[3] | 56,800 | 18,088–37,900 |
| Water Banking/Conjunctive Use | 0 | 50,870 |
| Flexible Storage Account | 0 | 4,684 |
| **Total Supplies** | **106,603–115,640** | **144,945–182,794** |
| **Total Supplies Above Demand** | **15,876–24,913[4]** | **45,145–82,994[5]** |

1. Complete buildout of DMS land uses is estimated to occur in 2015.
2. Source: *2000 UWMP*, December 2000, Tables 2-6 and 4-1, and the Santa Clarita Valley Water Report 2004, May 2005.
3. Consistent with the DWRSIM model, the figures show SWP allocation reduced in average years to approximately 59.7 percent of maximum allocation and in multiple dry years to approximately 39 percent of maximum allocation. The CALSIM II model projects that reliability in average years raises to approximately 75 percent and decreases to 20 percent in a single dry year. In any given year, the actual amount of SWP water deliveries could be above or below these model projections. Deliveries of water associated with the agency's SWP maximum allocation of 95,200 AFY are affected by a number of factors, including hydrologic conditions, the status of SWP facilities' construction, environmental requirements and evolving policies for the Bay-Delta. Programs are in place that has the potential to improve the reliability of imported water. As these programs are needed in dry years, they could be used up to the amounts indicated (as needed).
4. The surplus shown above is the net water available for injection into banking programs (e.g., Semitropic Groundwater Banking Project, other groundwater banking projects, etc.).
5. Dry year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these available supplies only in amounts necessary to meet demand.

The DMS Build-Out Scenario entails existing development, buildout of the near-term subdivision projects listed in the County's DMS, plus a portion of the Newhall Ranch Specific Plan, plus the project. The County's DMS lists all pending, recorded, and approved projects for which land divisions have been filed within County unincorporated lands and within the City of Santa Clarita. The City plus County unincorporated areas together constitute the County's Santa Clarita Valley Planning area.

*Table 5.8-9* illustrates both the cumulative water demand (existing plus DMS) and supply for the Santa Clarita Valley. This cumulative water demand is compared to the near-term projected Santa Clarita Valley water supplies and the additional Newhall Ranch Specific Plan water supplies. As shown, there is an adequate supply of water expected in both average years and dry years and no cumulative water supply impacts would occur. In fact, *Table 5.8-9* shows that water supplies exceed demand for the DMS Development Scenario by 15,876 to 24,913 AF in average years and by 45,145 to 82,994 AF in a single dry year. However, it should be noted that dry year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand. Based on the information provided in this analysis, the Soledad Village project is consistent with the General Plan DMS policies as they relate to water supplies.

**Santa Clarita Valley 2025 Buildout Scenario**

The Santa Clarita Valley 2025 Buildout Scenario entails buildout of lands under the current land-use designations indicated in the *County's Area Plan* and the *City of Santa Clarita's General Plan* by the year 2025, plus the proposed Soledad Village project, plus all known active pending General Plan Amendment requests for additional urban development in the County unincorporated area and the City of Santa Clarita.

*Table 5.8-10, Scenario 2: Santa Clarita Valley 2025 Buildout Scenario Water Supplies*, and *Table 5.8-11, Scenario 2: Santa Clarita Valley 2025 Buildout Scenario Water Demand and Supply*, summarize the cumulative water demand and supply for this build-out scenario. As shown, at partial buildout by the year 2020, there are adequate water supplies for the project. As a result, the Soledad Village project is not expected to create any significant cumulative water availability impacts in either average/normal or dry years. In addition, as shown, at buildout by the year 2025, there are adequate water supplies for the project, with no significant cumulative water supply impacts occurring in either average/normal or dry years. In fact, the two tables show that water supplies exceed demand under this scenario in average and dry years in both 2020 and 2025.

Dry year supplies available above demand reflect water supplies that would be available to purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand. For a critical dry year, when reliability of the SWP could be reduced, CLWA would utilize both dry-year supplies available from the Saugus Formation, and water banking and conjunctive use projects as indicated in *Table 5.8-10*.

**Table 5.8-10**
**Scenario 2: Santa Clarita Valley 2025 Buildout Scenario**
**Water Supplies**

| | Buildout (Year 2020) | | Buildout (Year 2025) | |
|---|---|---|---|---|
| | Average Years | Dry Years | Average Years | Dry Years |
| *Local Supply* | | | | |
| Groundwater | | | | |
| Alluvial Aquifer | 35,000 | 32,500 | 35,000 | 32,500 |
| Saugus Formation | 11,000 | 15,000–24,000 | 11,000 | 15,000–24,000 |
| Restored Impacted Wells | 0 | 10,000 | 0 | 10,000 |
| Saugus Formation (new wells) | 0 | 10,000 | 0 | 10,000 |
| Reclaimed Water | 17,000 | 17,000 | 17,000 | 17,000 |
| Newhall Ranch WRP Supply | 3,155 | 3,155 | 5,258 | 5,258 |
| *Imported Supplies* | | | | |
| CLWA SWP Table A Water[1] | 56,800 | 18,088–37,900 | 56,800 | 18,088–37,900 |
| Newhall Nickel Water | 0 | 0 | 1,468 | 1,607 |
| Newhall Semitropic Groundwater Bank Storage | 0 | 0 | 0 | 712 |
| Water Banking/Conjunctive Use, etc. | 0 | 90,870 | 0 | 90,870 |
| Flexible Storage Account | 0 | 4,684 | 0 | 4,684 |
| **Total Supply** | **122,955** | **201,297–230,109** | **126,526** | **205,719–234,531** |

Note:
1. SWP maximum allocation reduced in average years to approximately 59.7% of maximum allocation and in dry years to approximately 39.8% of maximum allocation. In any given year, the actual amount of SWP water deliveries could be above or below these model projections.

Source: *2000 UWMP*, December 2000, Tables 2-2, 2-6 and 4-1.

**Table 5.8-11**
**Scenario 2: Santa Clarita Valley 2025 Buildout Scenario**
**Water Demand and Supply**

| | Buildout (Year 2020) | | Buildout (Year 2025) | |
|---|---|---|---|---|
| | Average Years | Dry Years[5] | Average Years | Dry Years[5] |
| Total Build-Out Demand[2] | 113,100[1] | 124,410 | 123,176[3] | 135,494 |
| Santa Clarita Valley Water Supplies[4] | 122,955 | 201,297–230,109 | 126,526 | 205,719–234,531 |
| **Total** | **9,855** | **76,887–105,699** | **3,350** | **70,225–99,037** |

Notes:
1. Source: *2000 UWMP*, December 2000, Table 3-5 and the SB 610 Water Supply Assessment for the Soledad Village Project.
2. Demand is increased by approximately 10 percent in dry years.
3. Source: *2000 UWMP*, December 2000, Table 3-5, using a straight-line projection from 2020–2025.
4. Source: *2000 UWMP*, December 2000, Tables 2-2, 2-6 and 4-1.
5. Dry year supplies available above demand reflect water supplies that would be called upon by purveyors in dry years. Purveyors would typically secure water from these supplies only in amounts necessary to meet demand.

As depicted in *Table 5.8-10*, purveyors have access to an amount of water supplies that exceed demand during dry conditions. Therefore, no cumulatively significant water availability impacts would occur due to buildout of the Soledad Village project.

**CONCLUSION**

Because cumulative water supplies exceed demand, cumulative development (including the proposed Soledad Village project) would not result in unavoidable significant cumulative impacts on Santa Clarita Valley water resources. This includes potential impacts to groundwater resources related to recharge potential. Development of the proposed project site and other sites proposed for development in the Santa Clarita Valley, no significant project-specific or cumulative impacts would occur to the groundwater basin with respect to aquifer recharge. This is due to the fact that urbanization in the Santa Clarita Valley has been accompanied by long-term stability in pumping and groundwater levels, plus the addition of imported SWP water to the valley, which together have not reduced recharge to groundwater, nor depleted the amount of groundwater that is in storage within the valley. Therefore, cumulative mitigation measures are not required with respect to water resources.

***Mitigation Measures:*** No mitigation measures are required.

***Level of Significance After Mitigation:*** Not applicable.

## 5.8.5 UNAVOIDABLE SIGNIFICANT IMPACTS

Implementation of the proposed Soledad Village Project would not result in significant and unavoidable impacts to water supply and distribution facilities.

Pages omitted.

Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

# Attachment 23-C

City of Santa Clarita

# Gate-King Industrial Park

## *Final* Environmental Impact Report

State Clearinghouse Number 2001021121

*June 2003*

Pages omitted.

Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

# EXECUTIVE SUMMARY

This section summarizes the characteristics of the proposed project, the environmental impacts associated with the project, and measures recommended to mitigate identified significant impacts.

## PROJECT SYNOPSIS

### Project Applicant

The project applicant is Gate King Properties, LLC.

### Project Description

The applicant is proposing to subdivide the 584-acre project site into 60 lots and is requesting General Plan amendments to change the land use designations in several areas of the site. The proposal involves amending the land use designation on about 223 acres, or about 38% of the site. The proposed changes would eliminate the residential (RE) and commercial (CC) designations from the site, and would increase the area designated IC from 337.5 acres to about 344 acres. The area designated OS would increase from 93.2 acres to about 240 acres.

Lots 1-41, which encompass about 35% of the site, are proposed to be industrial/business park lots. Lots 42-44, which comprise about 1.8 acres, would accommodate two water tanks to serve site development. Lots 45-54, which comprise about 16% of the site, consist of landscaped slopes and trails. Lots 55-59, which comprise about 38% of the site, would be designated as permanent open space. The remainder of the site would consist of rights-of-way, including public streets (29.2 acres) and the MTA (14 acres) and SCE (19.3 acres) rights-of-way.

Full buildout of the site under the applicant's proposal would involve the development of about 170.1 acres (29.1% of the site) with industrial/commercial uses. This acreage would accommodate up to about 4.45 million square feet of industrial/commercial development. An additional 64.3 acres (11% of the site) would be rights-of-way (SCE, MTA, roads) and water wells. The remaining 349.6 acres (59.9% of the site) would include a combination of slopes, trails, areas within industrial/commercial lots that would not be developed due to the presence of large oak groves, and natural open space.

## ALTERNATIVES

As required by CEQA, the EIR examines a range of alternatives to the proposed project. Studied alternatives include:

- **No Project (Alternative 1)** – This option assumes that the project is not constructed, and that the site remains in its current condition.
- **Buildout Under Los Angeles County General Plan and Zoning (Alternative 2)** – This alternative considers the impact of buildout of the project site in accordance with the land uses prescribed in the Santa Clarita General Plan. About 31 residences and 4.9

million square feet of commercial and industrial development could be built under this alternative.

- **Ridgeline Preservation (Alternative 3)** – This alternative entails a reconfiguration of the project primarily to reduce grading of the Primary ridgeline onsite. Lots 17-22, 24-29, and 31-38 would be designated as open space and therefore would not be developed with industrial commercial uses as proposed. Also, 'C' Street, 'B' Street, and the segments of 'A' Street between lots 29 and 16 would be eliminated. This alternative would involve about 2.04 million square feet of commercial/ industrial development on about 67 buildable acres.
- **Oak Tree Preservation (Alternative 4)** – This option considers designation of development lots 9, 14, 15, 23, and 26- 38 as permanent open space to avoid impacts to several large clusters of oak trees. Landscape lots 50-53 would also be left as undeveloped open space. In addition, neither 'B' Street nor 'C' Street would be constructed and the extension of 'E' Street to connect to Pine Street would be eliminated. Buildout under this alternative would involve about 2.26 million square feet of industrial commercial development on about 71.3 acres.
- **Reconfigured 'C' Street (Alternative 5)** – This alternative, suggested by the project applicant, would eliminate all but about the 900 northernmost feet of 'C' Street and would eliminate most of the planned development along 'C' Street. Specifically, proposed industrial commercial lots 24-27 and the adjacent 8.8-acre landscape slope area would be left as permanent open space. One new industrial commercial lot would be added at the end of the reconfigured 'C' Street. This alternative would include about 4.2 million square feet of industrial commercial development on about 159.8 acres.

Each of the alternatives would be environmentally superior to the proposed project in at least one issue area. The No Project Alternative shows up as environmentally superior for each issue area as it would have no impact. However, that alternative would not fulfill the basic objective of the project. In addition, the No Project alternative would not preclude the site from eventual development in accordance with the existing General Plan designation for the site.

Of the development scenarios, only Alternative 2 (General Plan buildout) would involve more overall development than the proposed project and would have generally greater environmental impacts. Alternatives 3, 4, and 5 involve less overall development than the proposed project and would therefore reduce overall demands upon local services and infrastructure. Alternative 3 would involve the least overall development and would have the greatest benefits as compared to the proposed project with respect to ridgeline grading. Alternative 4 would reduce impacts to oak trees and associated habitat to the greatest degree. Either of these could be considered the environmentally superior alternative overall.

# SUMMARY OF IMPACTS AND MITIGATION MEASURES

Table ES-1 includes a brief description of the environmental issues relative to the proposed project, the identified environmental impacts, proposed mitigation measures, and impacts after mitigation. Impacts are categorized by class. Class I impacts are defined as significant, unavoidable adverse impacts which require a statement of overriding considerations to be issued per Section 15093 of the *State CEQA Guidelines* if the project is approved. Class II impacts are significant adverse impacts that can be feasibly mitigated to less than significant levels and which require findings to be made under Section 15091 of the *State CEQA Guidelines*. Class III are considered less than significant impacts.

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| ***LAND USE AND PLANNING*** | | |
| **Impact LU-1** The proposed development generally would not create compatibility conflicts with residential, commercial and industrial uses in the project vicinity. This impact is considered Class III, *less than significant.* | Mitigation measures recommended in Sections 4.7, *Noise,* and 4.11, *Aesthetics,* would minimize compatibility conflicts with surrounding land uses. | Less than significant. |
| **Impact LU-2** The proposed project would add an estimated 6,527 jobs within the City. Because this increase in employment is within citywide projections, this impact is considered Class III, *less than significant.* | None required. | Less than significant. |
| **Impact LU-3** The proposed project is considered generally consistent with City Land Use Element goals and policies, but is potentially inconsistent with City policies pertaining to preservation/ protection of significant ridgelines and oak trees. | Mitigation measures contained in Sections 4.6, *Biology*, 4.11, *Aesthetics,* 4.9, *Public Services,* 4.10, *Utilities,* and 4.12, *Cultural Resources,* would attain consistency with City General Plan goals and policies to the degree feasible. The following findings would need to be adopted for the proposed project. Various findings with respect to General Plan and Unified Development Code Consistency would need to be made to approve the project. A complete listing of these findings can be found in Section 4.1 *Land Use and Planning.* | The Planning Commission would need to make a finding that the project complies with the Ridgeline Preservation and Hillside Development Ordinance and Guidelines if it were to approve the project. |
| **Impact LU-4** The proposed project appears to fully or partially implement most relevant policies of the Regional Comprehensive Plan and Guide. | Mitigation measures included in Sections 4.2, *Geology*, 4.3, *Hydrology and Water Quality*, 4.4, *Air Quality*, and 4.6, *Biological Resources*, would achieve compliance with SCAG policies to the degree feasible. | The project appears to fully or partially implement most relevant SCAG policies. |
| ***GEOLOGY*** | | |
| **Impact GEO-1** The project site's potential to experience ground rupture is considered low. Nevertheless, impacts relating to ground rupture are considered Class II, *significant but* | The following measure is recommended to address potential concerns about the Beacon Fault.<br>**GEO-1** The significance of the Beacon Fault shall be verified at the Grading Plan stage. | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| *mitigable*, due to the presence of the Beacon Fault onsite. | During site grading, the final at-grade fault location shall be determined, and, as required by the City Engineer, the location and width of the setback shall be adjusted accordingly. | |
| **Impact GEO-2** The project site would experience substantial groundshaking in the event of an earthquake on any of several faults. However, compliance with UBC requirements would reduce such impacts to a Class III, *less than significant* level. | The project site would experience substantial groundshaking in the event of an earthquake on any of several faults. However, compliance with UBC requirements would reduce such impacts to a Class III, *less than significant* level. | Less than significant. |
| **Impact GEO-3** The project site has a low potential for ground failure. Impacts relating to ground failure are considered Class III, *less than significant.* | None required. | Less than significant. |
| **Impact GEO-4** The project involves grading and development in steeply sloped areas with high landslide potential. Potential impacts relating to landsliding are considered Class II, *significant but mitigable.* | **GEO-4(a)** A definitive determination of potential debris flow hazard shall be completed as a part of a review of 1 inch = 40 feet scale grading plans. Specific mitigation measures for debris flow hazard may consist of avoidance, debris walls or debris basins designed to contain the anticipated volume of debris, building setbacks from the potential debris flow hazard area, or removal of the material susceptible to debris flow.<br><br>**GEO-4(b)** A more detailed analysis of cut slopes shall be performed at the grading plan stage once 1"=40' scale plans are available. Cut-slopes that will expose bedrock disrupted by the Beacon Fault may also require stability fills to mitigate the potential for surficial instability, and should be evaluated at the Grading Plan stage.<br><br>The stability of bedding planes below the proposed buttresses shall also be analyzed and presented at the grading plan stage utilizing piezometric surfaces where applicable. A declaratory statement needs to be made in the slope stability section of the report that justifies the use or omission of groundwater (piezomertric surfaces) in the slope stability analyses. Per RTF&A the temporary stability of the backcuts for the recommended stability fills and buttresses will also need to be demonstrated at the grading plan stage along with any backcuts required for the removal of landslides, alluvium or artificial fill. Future anticipated loads from water tanks, buildings or other significant structures should also be incorporated into the stability calculations at the grading plan stage. | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | **GEO-4(c)** The future anticipated load(s) from the proposed water tank(s) shall be incorporated into the stability calculations at the Grading Plan stage along with any anticipated future groundwater.<br><br>**GEO-4(d)** The areas of deep (>40 feet thick) proposed fills shall be evaluated further at the grading plan stage. Any additional requirements of the City Engineer shall be fully implemented.<br><br>**GEO-4(e)** Recommended removal depths shown on RTF&A's Figure 2.1 (report 10/22/01) range from 3 to 70 feet. The deep removals shall be analyzed in detail at the grading plan stage relative to groundwater conditions and backcut stability. Per RTF&A (2001), uncertified existing fills will be removed prior to the placement of compacted fill. Any unsuitable materials underlying the fills shall also be removed.<br><br>**GEO-4(f)** In order to reduce the potential for erosion, all cut and fill slopes should be seeded or planted with proper ground cover as soon as possible following grading. The ground cover should consist of drought-resistant, deep-rooting vegetation. A landscaping expert should be consulted for ground cover recommendations.<br><br>**GEO-4(g)** Implement canyon subdrains in the main drainage areas to receive fill, and backdrains for buttress fills to help protect the proposed fills from groundwater infiltration.<br><br>**GEO-4(h)** Per standard grading practices, water shall not be allowed to stand or pond on the future graded building pads nor should it be allowed to flow over natural or constructed slopes, but should be directed to the natural slope drainage devices. | |
| **Impact GEO-5** Some onsite soils are potentially expansive. This is considered a Class II, *significant but mitigable impact.* | **GEO-5** If potentially expansive units are encountered in the final pad or street grades, they shall be evaluated by the Project Geotechnical Engineer. Special foundation designs and reinforcement can be utilized to mitigate expansive material. Optionally, the expansive material can be removed to a specified depth determined by the Project Geotechnical Engineer and replaced with compacted fill with very low to non-expansive characteristics, or the expansive soil may be treated with additives to lower the expansion index. | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| ***HYDROLOGY AND WATER QUALITY*** | | |
| **Impact H-1** During project construction, the soil surface would be subject to erosion and the downstream watershed would be subject to pollution. However, compliance with the requirements of the NPDES permit would reduce these impacts to a less than significant level (Class III). | Implementation of BMPs to be developed as part of the SWPPP for the site would be required (see above). Additional mitigation is not required. | Less than significant. |
| **Impact H-2** The proposed project would increase impervious surface and runoff to Newhall Creek, which could increase the potential for downstream flooding and stream channel erosion. This is considered a Class II, *significant, but mitigable impact.* | **H-2(a)** The drainage plan for the project shall include post-development designs for detention basins and on-site infiltration to reduce $Q_{50B}$ peak discharge to the pre-development level for Newhall Creek. The Los Angeles Flood Control District and the City of Santa Clarita Engineer shall review all hydrology and drainage plans for the site to determine if the drainage plans adequately reduce peak flows to predevelopment levels.<br><br>**H-2(b)** The RCB under Sierra Highway shall be improved to have adequate capacity to accommodate the Capital Flood. Additionally, the natural channel approaching the RCB shall be improved to prevent flooding of the Highway. Alternatively, a retention basin with adequate capacity to eliminate the need for improvement of the RCB can be provided at the Hondo Oil and Gas site.<br><br>**H-2(c)** Onsite drainage facilities for the developed areas shall be designed for the 25-year Urban Design Storm. The 50-year Capital Flood storm shall be used for all open channels, closed conduits under major and secondary road, and detention facilities.<br><br>**H-2(d)** Slope protection along Railroad Canyon and Newhall Creek shall be designed to meet LACPWD standards. Rock riprap slope protection side slopes shall not be greater than 2:1 and gunite side slopes shall be no greater than 1.5:1. | Less than significant. |
| **Impact H-3** Portions of the site are within the 100-year flood zone and may therefore be subject to flooding. This is considered a Class II, *significant, but mitigable impact.* | **H-3(a)** The finished floor elevation of the buildings within the A and AO zones shall be a minimum of 1 foot above the existing adjacent grade.<br><br>**H-3(b)** The applicant shall obtain a revision to the Flood Insurance Rate Map. This process will first entail a conditional letter of map revision (CLOMR). Then, after the project is built, a letter of map revision | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | (LOMR) showing the actual "as built" plans shall be submitted. FEMA will require that the CLOMR and LOMR indicate, with supporting technical data, how the sites will be protected from erosive forces. This can be accomplished in a variety of ways, including demonstrating non-erosive velocities or placement of rock rip rap along the channel. | |
| **Impact H-4** With the proposed project, runoff to Newhall Creek could be adversely affected with pollutants such as oil, pesticides, and herbicides. This is considered a Class II, significant but mitigable impact. | **H-4** A Storm Water Management Plan that incorporates Best Management Practices (BMPs) for the long-term operation of the site shall be developed and implemented by the applicant to minimize the amount of pollutants that are washed from the site. The plan shall be developed in accordance with the requirements of the City of Santa Clarita. Examples of BMPs that apply to both initial development of the lots and to long-term operation of the project are listed below.<br><br>*Education*<br>• Stencil all storm drains inlets and post signs along channels to discourage dumping by informing the public that water flows to the Santa Clara River<br>• Provide educational flyers to each new building unit regarding toxic chemicals and alternatives for fertilizers, pesticides, cleaning solutions and automotive and paint products.<br>• Provide educational flyers to each new building unit regarding proper disposal of hazardous waste and automotive waste.<br><br>*Source Reduction/ Recycling*<br>• Development of an integrated pest management program for landscaped areas of the project. These areas would include slope-stabilization landscaping, and commercial area landscaping. Integrated pest management emphasizes the use of biological, physical, and cultural controls rather than chemical controls. Examples include use of insect resistant cultivars, manual weed control, use of established thresholds for pesticide and herbicide application, use of chemical controls that begin preferentially with dehydrating dusts, insecticidal soaps, boric acid powder, horticultural oils, and pyrethrinbased insecticides.<br><br>*Cleaning/ Maintenance* | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | • Routine cleaning of streets, parking lots and storm drains. Regular maintenance and cleaning of catch basins, debris basins, and siltation basins; maintenance logs shall be regularly submitted to the appropriate agencies.<br><br>*Structural Treatment Methods*<br>• Catch basin inserts or storm drain devices such as storm cepters shall be installed with the initial development. The use of vegetated swales and strips, infiltration basins of oil separators as needed to manage stormwater pollution from each developed lot shall be provided at the time the buildings are constructed.<br>• Trash storage areas and storage areas for materials that may contribute pollutants to storm water shall be covered by a roof and protected from surface runoff. | |
| ***AIR QUALITY*** | | |
| **Impact AQ-1** Construction activity associated with the proposed project would result in the emission of air pollutants, including fugitive dust. Because emissions would exceed SCAQMD significance thresholds, construction impacts are considered Class I, *unavoidably significant.* | **AQ-1(a)** Water trucks shall be used during construction to keep all areas of vehicle movement damp enough to prevent dust from leaving the site. Increased watering is required whenever wind speed exceeds 15 mph. Grading shall be suspended if wind gusts exceed 25 mph.<br><br>**AQ-1(b)** The amount of disturbed area shall be minimized and on-site vehicle speeds shall be kept to 15 mph or less.<br><br>**AQ-1(c)** Soil with 5% or greater silt content that is stockpiled for more than two days shall be covered, kept moist, or treated with soil binders to prevent dust generation. Trucks transporting material shall be tarped from the point of origin or shall maintain at least two feet of freeboard.<br><br>**AQ-1(d) Fugitive Dust Control Measures**<br>• All material excavated or graded shall be sufficiently watered to prevent excessive amounts of dust. Watering should occur at least twice daily with complete coverage, preferably in the late morning and after work is done for the day.<br>• All clearing, grading, earth moving, or excavation activities shall cease during periods of high winds (i.e., greater than 20 mph averaged over one hour) so as | Unavoidably significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | to prevent excessive amounts of dust.<br>• All material transported off-site shall be either sufficiently watered or securely covered to prevent excessive amounts of dust.<br>• The area disturbed by clearing, grading, earth moving, or excavation operations shall be minimized so as to prevent excessive amounts of dust.<br>• All inactive portions of the construction site shall be seeded and watered until grass cover is grown; or, a sealer is placed over these portions of the site.<br>• All active portions of the construction site shall be sufficiently watered to prevent excessive amounts of dust.<br><br>**AQ-1(e) General Dust Controls**<br>• All areas with vehicle traffic should be watered periodically, at a minimum, this will require twice daily applications (once in late morning and once at end of workday).<br>• Streets adjacent to the project site shall be swept as needed to remove silt that may have accumulated from construction activities so as to prevent excessive amounts of dust.<br><br>**AQ-1(f) Ozone Precursor Control Measures:**<br>• Equipment engines shall be maintained in good condition and in proper tune as per manufacturer's specifications.<br>• New technologies to control ozone precursor emissions shall be used as they become available in the future.<br>• The applicant shall use low-VOC architectural coatings in construction whenever feasible and shall coordinate with the SCAQMD to determine which coatings would reduce VOC emissions to the maximum degree feasible. | |
| **Impact AQ-2** Operational emissions associated primarily with projec-generated traffic would exceed SCAQMD significance thresholds for ROC and $NO_x$. This is considered a Class I, *unavoidably significant* impact. | The proposed project includes a number of features designed to provide transportation alternatives that minimize air emissions. These include the provision of sidewalks and ample landscaping along all project site roads, and a network of hiking/ equestrian trails through the portions of the site that would remain undeveloped. To further reduce emissions associated with the proposed project, the following measures are recommended:<br><br>**AQ-2(a)** On-site industrial structures shall be | Unavoidably significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | fitted with photovoltaic roof tiles or other technologies that allow the use of solar energy for heating and lighting to the maximum degree feasible.<br><br>**AQ-2(b)** Energy-efficient windows shall be installed in all buildings.<br><br>**AQ-2(c)** On-site parking areas shall be designed to accommodate electric vehicle charging stations. | |
| **Impact AQ-3** Project traffic, together with other cumulative traffic increases in the area, would increase carbon monoxide concentrations at some area intersections. However, because concentrations would remain below state and federal standards, this impact is considered Class III, *less than significant.* | None required. | Less than significant. |
| ***TRANSPORTATION AND CIRCULATION*** | | |
| **Impact TC-1** The proposed project would generate significant traffic impacts under City criteria at 13 of 19 study area intersections under existing + project conditions. These impacts are considered Class II, *significant but mitigable.* | Table 4.5-7 summarizes mitigation measures in the form of intersection improvements that effectively mitigate the project's direct impacts. | Less than significant. |
| **Impact TC-2** The proposed project would generate significant traffic impacts under City criteria at 10 of 19 study area intersections under interim year + project conditions. These impacts are considered Class II, *significant but mitigable* | Intersection and roadway improvements will be required in order to maintain acceptable levels of service in the future. Table 4.5-9 in Section 4.5 summarizes these improvements and lists the proposed project's percent share of the improvement. Also included in the table are the ICU values that result from applying the recommended mitigation. For locations where "with-project" conditions are LOS B or better, mitigation consists of payment of Bridge and Thoroughfare District Fees in lieu of specific improvements for that location. | Less than significant. |
| **Impact TC-3** Installation of traffic signals is warranted at each of the new intersections created by the project as well as at the existing Pine Street/San Fernando Road and SR-14 Southbound ramps/San Fernando Road intersection. These impacts are considered Class II, *significant but mitigable.* | In conjunction with project development, traffic signals shall be added at the following intersections:<br><br>141. SR-14 SB Ramp & San Fernando Road<br>215. Pine Street & San Fernando Road<br>216. 'A' Street & San Fernando Road<br>217. Sierra Highway & 'A' Street | Less than significant. |
| **Impact TC-4** The proposed project | The following mitigation measures are | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| would not create any significant impacts under Los Angeles County CMP criteria. Impacts relating to CMP criteria are considered Class III, *less than significant.* | recommended to meet Santa Clarita Transit bus stop requirements:<br><br>**TC-4(a)** Bus stop improvements shall be installed at the following locations:<br><br>• Southbound 'A' Street, near side of "E" Street<br>• Southbound 'A' Street, at lot line of lots 18 and 19<br>• Southbound 'A' Street, far side of 'C' Street<br>• North bound 'A' Street, far side of 'C' Street<br>• Northbound 'A' Street, opposite lot line of lots 18 and 19, adjacent to water tank access road<br>• Northbound 'A' Street, far side of "E" Street<br>• Northbound Sierra Highway, far side of 'A' Street<br>• Westbound San Fernando Road, far side of 'A' Street<br>• Eastbound San Fernando Road, near side of 'A' Street<br><br>**TC-4(b)** All bus stop locations shall be equipped with 10 foot by 20 foot concrete pads placed behind the sidewalk. Concrete pads may require the dedication of additional right-of-way. In a bus stop location, the sidewalk shall touch the street for a length of no less than 80 feet.<br><br>**TC-4(c)** With respect to the bus stops at the locations of westbound San Fernando Road, far side of 'A' Street, and eastbound San Fernando Road, near side of 'A' Street, the following requirements shall apply:<br><br>• The stops shall be equipped with bus turnouts and permanent stylized bus shelters.<br>• The shelter shall include a bench and trash receptacle.<br>• Architecture of the shelter shall be approved by City staff.<br>• The shelter shall be hard wired for lighting.<br>• Bus turnouts shall require an additional 12 feet of right-of-way to accommodate their width.<br><br>**TC-4(d)** At all intersections where there are bus stops, there shall be a safe, traffic-controlled way to cross the street. This may be | |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | accomplished by either traffic signals, stop signs, or pedestrian overcrossings. At intersections where there are traffic signals or stop signs, crosswalks shall be provided on all four sides of the intersection.<br><br>**TC-4(e)** The project applicant shall provide a park-and-ride lot at the intersection of San Fernando Road and 'A' Street, or funds in lieu of the lot as provided by the Development Agreement.<br><br>**TC-4(f)** Although transit impact fees do not apply to the project at this time, the applicant shall pay any fees that may be in place at the time of building permit issuance. | |
| **Impact TC-5** The proposed development would need to provide an estimated 8,891 overall parking spaces to serve the project. Assuming that each individual development onsite complies with its Code requirements for parking, impacts to parking would be Class III, *less than significant.* | None required beyond compliance with the parking requirements outlined in the City's Unified Development Code. | Assuming compliance with applicable parking requirements, no significant impacts are anticipated. |
| ***BIOLOGICAL RESOURCES*** | | |
| **Impact BIO-1** Project development would result in the direct permanent loss, and indirect degradation and fragmentation of several "common" habitat types onsite, including Mixed Chaparral, Riversidean Sage Scrub, and Annual Grassland habitats. This is considered a *significant but mitigable* impact (Class II). | **BIO-1(a)** Landscaping within fire clearance zones shall include native species indigenous to the region. Modification of fire hazard fuels shall be limited to hand thinning of individual shrubs, clearing dead fuel, replanting with fire-resistant plants indigenous to the area, or other methods to attain fire safety while producing a viable natural and native vegetation community. No species identified as invasive on the CNPS, Channel Islands Chapter *Invasive Plants List* (1997) shall be utilized in the landscape plans and all landscaping plans shall be prepared by the City and approved by the City and the County Fire Department.<br><br>**BIO-1(b)** Revegetation and landscaping plans for the graded road areas onsite shall be prepared and approved by the City before each phase of the proposed project. Plant species, seed mixes, weed suppression, and planting methodology, and irrigation schedule shall be approved by a qualified biologist or landscape architect and shall utilize native species from onsite habitats. No species identified as invasive on the CNPS, Channel Islands Chapter *Invasive Plants List* (1997) shall be utilized in the landscape plans and all landscaping plans shall prepared by the City and approved by the City and Fire Department. | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| **Impact BIO-2** The proposed project may cause the direct loss of special-status plants identified as List 1B or 4 species by the California Native plant Society (CNPS). This is a Class II, *significant but mitigable,* impact. | **BIO-2** Prior to grading of each development phase, focused surveys shall be conducted during the prior flowering season for the slender and Plummer's mariposa lilies to determine the presence or absence of those special-status plants. If no specimens are found within the development footprint or fire clearance zone, then no additional mitigation is required.<br><br>In the event either slender or Plummer's mariposa lilies are identified within the development or fire clearance areas, the applicant shall submit a special-status plant restoration plan for review and approval by a City of Santa Clarita Planning Department approved biologist. Target sites for mitigation shall be sampled for soil type and habitat criteria sufficient for the establishment and growth of the affected special-status species. The plan shall additionally include, but not be limited to, the following components:<br><br>1) Performance criteria (i.e., what is an acceptable success level of revegetation to mitigate past impacts);<br>2) Monitoring effort (who is to check on the success of the revegetation plan, and how frequently);<br>3) Contingency planning (if the effort fails to reach the performance criteria, identify the remediation steps need to be taken); and<br>4) Irrigation method/schedule (how much water is needed, where, and for how long). | Less than significant. |
| **Impact BIO-3** Development of the proposed project could potentially affect the San Fernando Valley spineflower (SFVS), if present onsite. Potential impacts to this species would be considered Class II, *significant but mitigable.* | Due to the extreme rarity of the SFVS and its known presence at only two locations, the following mitigation measures are required.<br><br>**BIO-3(a)** In the April-June prior to onsite grading and development of each phase, a survey for the SFVS shall be conducted by a qualified biologist in all Mixed Chapparal, Riversidean Sage Scrub, Annual Grassland, and Disturbed areas where ground disturbance is anticipated. If no SFVS are found, no further mitigation is required. In the event the SFVS is discovered onsite, mitigation measures B-3 (b-d) shall be required.<br><br>**BIO-3(b)** In the event the SFVS is discovered onsite, the current and anticipated | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | future distribution of the species shall be mapped by a qualified biologist. The CDFG and City of Santa Clarita shall be formally notified and consulted regarding the presence of this species onsite. If the SFVS becomes federally listed prior to grading of the site, the USFWS shall also be notified. A preservation and management plan shall be prepared for the SFVS by a qualified biologist and shall include, but not be limited to, the following:<br><br>• Project development shall be located no closer than 200-feet to any SFVS that may be found onsite. This buffer zone shall be designated with appropriate fencing to exclude construction vehicles and public access, but not wildlife access;<br>• Stormwater runoff, irrigation runoff, and other drainage from developed areas shall not pass through areas populated by the SFVS;<br>• Spineflower areas shall not be artificially shaded by structures or landscaping within the adjacent development areas;<br>• Pesticide use shall not be permitted within SFVS areas;<br>• The agency responsible for monitoring the SFVS area during construction and after project completion shall be identified and the frequency and extent of monitoring shall be determined.<br><br>**BIO-3(c)** In the event it is determined that project development could potentially affect the SFVS, the CDFG shall be contacted to determine the need for a "take permit" under the California Endangered Species Act. If the SFVS is federally listed prior to site grading, the USFWS shall be contacted to determine the need for a take permit under the federal Endangered Species Act. Appropriate mitigation required to minimize or mitigate impacts to the SFVS shall be implemented and may include the following: the creation of a spineflower preserve, establishment of vegetated buffers or other setbacks, drainage modification of the adjacent areas, SFVS revegetation, and monitoring to ensure success of the mitigation. | |
| **Impact BIO-4** The proposed project would directly remove up to 1,100 healthy oak trees and 709 dead or fire damaged oaks, and could indirectly | **BIO-4(a)** All direct impacts to oak trees on site shall be avoided wherever feasible. For oak trees that are affected, an oak tree mitigation program shall be developed pursuant to the | Unavoidably significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| disturb an estimated 551 individual oak trees. An estimated 69 acres, or approximately 34%, of the oak woodland/ forest habitat onsite would be affected. Impacts to oak woodland/forest habitat are considered Class I, *unavoidably significant.* | City's oak tree preservation ordinance. This mitigation program shall include, but not be limited to:<br>• Identifying specific protective measures for protecting and maintaining all oaks within potential encroachment areas;<br>• Mature oak trees and shrubs shall not be removed during preparation of fire clearance zones;<br>• Replacement tree planting, maintenance, and monitoring specifications, which shall at the minimum include the following:<br>1) Performance and success criteria to ensure that at least 80% of the 500 planted coast live oak trees survive for at least five years;<br>2) Monitoring effort (who is to check on the success of the revegetation plan, and how frequently);<br>3) Contingency planning (if the effort fails to reach the performance criteria, identify the remediation steps needed to be taken);<br>4) Irrigation method/schedule (how much water is needed, where, and for how long); and<br>5) A final map, corresponding spreadsheet, and impact summary table indicating all oaks to be removed and that reflects impacts resulting from the final approved project.<br>6) All native California oak trees removed as a result of project implementation shall be replaced with in-kind native California oak tree specimens obtained from regional (i.e., Santa Clarita Valley) stock.<br><br>**BIO-4(b)** The proposed open space wilderness area and any other wildlife/corridor easement areas and/or fee transfers per previous City agreements shall be deeded and/or secured with the City at the time of final tract map approval. | |
| **Impact BIO-5** The proposed development would cause direct and indirect impacts to CDFG and Corps jurisdictional drainages onsite. This is a Class II, *significant but mitigable* impact. | Compliance with the requirements of the appropriate Corps, CDFG, and RWQCB permits, and implementation of any mitigation measures contained therein, would offset the loss of waters of the U.S. and waters of the state. As discussed in Section 4.3, Hydrology and Water Quality, a National Pollution Discharge Elimination System (NPDES) permit is required for development of the | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | proposed project. As a result Best Management Practices (BMPs) would be required to minimize impacts to water quality and quantity both onsite and offsite during construction. No additional mitigation is required beyond that specified in Section 4.3, Hydrology.<br><br>Although the Corps and CDFG will require specific mitigation as part of their permitting processes, the following measures provide minimum requirements for the project.<br><br>**BIO-5(a)** Impacts to jurisdictional waters shall be mitigated at a minimum ratio of 2:1.<br><br>**BIO-5(b)** The project applicant shall provide a buffer between development and I riparian habitat associated with drainage FF, which is located directly south of the Eternal Valley Cemetery, as required by CDFG. | |
| **Impact BIO-6** The proposed development would disrupt wildlife movement corridors through the project area, and between the open space areas associated with the San Gabriel and Santa Susana Mountains. This impact is considered *unavoidably significant* (Class I). | **BIO-6(a)** The open space area in lot 55 shall be maintained for continued wildlife access. Dense native vegetation reflecting species currently present onsite shall be planted along the borders of these areas as necessary to provide appropriate cover and resources for wildlife. A pathway for animal movement shall be located between the vegetated buffers.<br><br>**BIO-6(b)** Solid barrier fencing onsite shall be prohibited around areas that border open spaces or routes of animal movement. Fencing in these areas shall consist of "ranch style" post fencing or barb-wire style fencing. Fencing shall allow at least one-foot of clearance above ground to permit wildlife movement.<br><br>**BIO-6(c)** Wildlife guzzlers (2) shall be constructed in open space areas along wildlife movement corridors in locations to be determined by a qualified biologist.<br><br>**BIO-6(d)** The following low-light design features shall be implemented adjacent to open space and wildlife corridor areas:<br><br>• Low sodium lights shall be used on all roadways to reduce glare and direct it away from wildlife corridor and open space areas;<br>• Streetlight poles shall be of an appropriate height to reduce the glare and pooling of light into open space and corridor areas; | Unavoidably significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | and<br>• Street light elements shall be recessed or hoods shall be used to reduce glare impacts on open space and corridor areas. | |
| **Impact BIO-7** The proposed development may cause the direct loss of special-status wildlife through conversion of onsite habitats to developed areas. Indirect impacts on special-status wildlife species could occur through the habitat fragmentation and degradation because of the introduction of non-native plants. This impact is considered *significant but mitigable* (Class II). | **BIO-7(a)** Two weeks prior to removal of trees during the raptor nesting season (February through October), a survey for raptor nests shall be made by a qualified biologist. If active nests are located, then all construction work must be conducted at least 500 feet from the nest until the adults and young are no longer dependent upon the nest site.<br><br>**BIO-7(b)** Not more than two weeks prior to ground disturbing construction within Mixed Chaparral, Riversidean Sage Scrub, and Annual Grassland habitats, a preconstruction survey for the coast horned lizard, coastal western whiptail, coast patch-nosed snake, rosy boa, California horned lark, the Southern California rufous–crowned sparrow and any other special-status species shall be conducted by a qualified biologist. As all potential special-status species that may occur in these habitats are Species of Concern and not formally listed, any individuals found shall be captured, when possible, and transferred to adjacent appropriate habitat within the open space/wilderness preserve onsite. | Less than significant. |
| ***NOISE*** | | |
| **Impact N-1** Construction activity would temporarily generate high noise levels on-site. Because noise could exceed thresholds in the City Noise Ordinance, impacts are considered Class II, *significant but mitigable.* | **N-1(a)** All diesel equipment shall be operated with closed engine doors and shall be equipped with factory-recommended mufflers.<br><br>**N-1(b)** Whenever feasible, electrical power shall be used to run air compressors and similar power tools.<br><br>**N-1(c)** For all construction activity on the project site, noise attenuation techniques shall be employed as needed to ensure that noise remains below 80 dBA in commercial/industrial areas and below 65 dBA at residences. Such techniques include, but are not limited to, the use of sound blankets on noise generating equipment and construction of temporary barriers between construction sites and affected uses. | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| **Impact N-2** Daytime operations are not expected to violate the City Noise Ordinance, but noise levels could exceed Noise Ordinance standards for nearby residential uses if on-site truck activity occurs at night. Impacts relating to project operation are therefore considered Class II, *significant but mitigable*. | The following measures are recommended to minimize the potential for noise disturbance.<br><br>**N-2(a)** Loading dock operations on Lots 2-4, 7- 9, 14, and 15 shall be oriented away from residential areas.<br><br>**N-2(b)** Onsite trash pickup services, street and parking lot sweeping, and truck deliveries shall be restricted to between the hours of 7:00 AM and 6:00 PM. | Less than significant. |
| **Impact N-3** Project-generated traffic would incrementally increase traffic noise levels along major roadways in the site vicinity. However, the increases would be less than the significance thresholds; therefore, project-related traffic noise impacts are considered Class III, *less than significant*. | Significant impacts are not anticipated; therefore, mitigation is not required. | Less than significant. |
| ***HUMAN HEALTH AND SAFETY*** | | |
| **Impact HHS-1** Several areas on-site potentially have soil and/or groundwater contamination that could pose a risk to human health and safety. This is considered a Class II, *significant but mitigable* impact. | **HHS-1(a)** The sampling program outlined below shall be implemented prior to issuance of grading permits for areas suspected of being contaminated:<br><br>• Collect soil samples in the vicinity of the former or existing underground storage tanks on the Turner and Stevens property. Complete a geophysical survey to determine if the tanks are still present on the property.<br>• Collect soil samples from beneath the leach lines of the septic tank located on the Turner & Stevens property, formerly utilized by the Elmore Pipe Jacking Facility.<br>• Collect soil samples in the vicinity of any oil wells not previously sampled and any wells not scheduled for abandonment. Also, collect soil samples from directly beneath the former tank farm locations, formerly located on various areas of the property.<br>• Collect soil samples from near the current (SCE and ARCO) and former (Mobil) oil and gas pipeline easements located on the project site.<br>• Collect soil samples from near the railroad tracks located on the western portion of the property.<br>• Collect sediment samples from Newhall creek and its tributary located on the project site. | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | • Collect soil and groundwater samples on the project site adjacent to the border of the Newhall County Water District property.<br>• Collect groundwater samples from the project site adjacent to the former Newhall Refinery (across Sierra Highway).<br>• Collect soil and groundwater samples from the project site adjacent to the Historic Pioneer Refinery.<br>• Collect soil samples from beneath the three 5-gallon buckets of hydraulic oil observed on the Arklin property.<br><br>If contamination exceeding regulatory action levels is found in any of the above locations, appropriate remediation shall be undertaken prior to issuance of grading permits for the contaminated areas. Any remedial activity shall be conducted to the satisfaction of the appropriate regulatory oversight agency (for example, the County Health Department, Department of Conservation, Regional Water Quality Control Board, Department of Toxic Substances Control).<br><br>**HHS-1(b)** The debris and trash, including tires, electrical appliances, mattresses, abandoned automobile and trailer home and miscellaneous empty drums located on various portions of the property, including within Newhall Creek, shall be removed and properly disposed of offsite prior to issuance of grading permits. | |
| **Impact HHS-2** Disturbance of oil and gas lines on-site during site grading could potentially result in hazardous conditions for site workers. Implementation of appropriate safety precautions would reduce such impacts to a Class II, *significant but mitigable* level. | The following measures are recommended for all grading activity in the vicinity of onsite oil or gas pipelines.<br><br>**HHS-2(a)** Pipeline operators shall be notified in advance of any grading activity in the vicinity of an oil or gas pipeline. Any specific requirements of the operator to avoid disturbance that could create a safety hazard shall be fully implemented. Possible methods to protect underground utilities inlcude dielectric coating, cathodic protection, mortar coating or encase in cement-slurry or concrete.<br><br>**HHS-2(b)** Prior to grading in the vicinity of oil or gas pipelines, the locations of the pipelines shall be marked. Underground Service Alert shall be notified 48 hours in advance of grading and shall clear the | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | pipeline locations prior to grading activity. | |
| **Impact HHS-3** Project development would expose site workers to electromagnetic radiation from the high voltage overhead transmission line onsite. However, such hazards are considered Class III, *less than significant*. | None required. | Less than significant. |
| **Impact HHS-4** The project would introduce new industrial park development in the vicinity of the rail line along Pine Street. Although this would incrementally increase the potential for safety conflicts with rail activity, compliance with standard safety requirements would reduce such impacts to a Class III, *less than significant* level. | None required. | Less than significant. |
| ***PUBLIC SERVICES*** | | |
| **Impact PS-1** The proposed project would increase demand for fire protection service. However, provision of funding for additional fire protection equipment and facilities, and adherence to guidelines regarding access to all property would reduce the impact to fire protection service to a Class II, *significant but mitigable*, level. | **PS-1(a)** The applicant will provide a fire station site and a helo-pad site as provided in a separate agreement with the County Fire Department.<br><br>**PS-1(b)** Coordination with the Los Angeles County Fire Department is required in order to determine the need for a fire station within the development and its inclusion in the tract map. If the Fire Department requests an on-site station, a fire station site shall be provided on-site in a location satisfactory to the Department as provided in a separate agreement between the applicant and the County Fire Department.<br><br>**PS-1(c)** All applicable building codes and ordinance requirements for construction, access, water mains, fire hydrants, fire flows, brush clearance and fuel modification plans must be met. The Los Angeles County Fire Department has set forth specific guidelines regarding access issues. These guidelines are as follows:<br><br>• The roadway to every building shall be accessible by an all weather surface that is not less than the prescribed width, unobstructed and clear to sky and be extended to within 150' of all portions of the exterior walls.<br>• When a bridge is required as part of a fire access road, it shall be designed for a live load of a minimum of 75,000 pounds. | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | • The maximum allowable grade shall not exceed 15% except where the topography makes it impractical to keep within such a grade, and then an absolute maximum of 20% will be allowed for up to 150 feet in distance. The average maximum allowed grade, including topography difficulties, shall be no more than 17%. Grade breaks shall not exceed 10% in 10 feet.<br>• No portion of lot frontage shall be more that 200' via vehicular access from a public fire hydrant, and no portion of a building shall exceed 400 feet via vehicular access from a properly spaced public fire hydrant.<br>• A cul-de-sac shall not be more that 500' in length and shall have a turning radius of at least 42'; when extending beyond 200' a hydrant shall be required at the corner and mid-block<br>• On-site driveways shall provide a minimum unobstructed width of 26' clear to sky and are to be within 150 ' of all portions of the exterior walls of the first story of any building. Driveway widths are required to be greater than 26' depending on the height of the building and the amount of parking allowed on the access road.<br>• Limited access devises (gates etc.) shall be 26' wide if used for both directions of travel and 20' if used for one direction of travel. They shall be positioned 50' from a public right-of-way and shall have a turnaround with a minimum of a 32' radius. If an intercom system is used, the 50' shall be measured from the right-of-way to the intercom control device.<br>• Any proposals for traffic calming measures (speed bumps, traffic circles etc.) shall be submitted to the Fire Department for review prior to implementation. | |
| **Impact PS-2** The proposed project would be located in a Very High Fire Severity Zone as designated by the Los Angeles County Fire Department. Impacts relating to wildfire hazards are considered Class II, *significant but mitigable*. | **PS-2(a)** The applicant shall develop a Fuel Modification Plan for all development areas adjacent to or potentially exposed to wildfire hazard areas. The plan shall be subject to review and approval by the Los Angeles County Fire Department Fuel Modification Unit.<br><br>**PS-2(b)** The landscape palette for the project shall prohibit the use of highly flammable | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | species near areas of open space.<br><br>**PS-2(c)** Landscaping of manufactured slopes shall use plant species appropriate for use in fuel modification zones. Use of native plants shall maintain the natural landscape of the project area and will reduce the use of exotic and possibly invasive non-native species. | |
| **Impact PS-3** The project would generate a modest increase in demand for police services. Provision of funding for additional police protection personnel and equipment and adherence to the crime prevention guidelines suggested by the Los Angeles County Sheriff's Department would reduce the impacts to a *significant but mitigable* (Class II) level. | **PS-3** The project shall incorporate the following crime prevention measures:<br>• Adequate lighting in open areas and parking lots<br>• Visibility of doors and windows from public streets and between buildings<br>• Adequate parking spaces in all parking lots<br>• Well lit building address numbers that are large enough to be readily apparent from the street<br>• A four-lane roadway as the major street access through the site (note: this is consistent with the applicant's proposal) | Less than significant. |
| **Impact PS-4** The proposed project would not directly generate additional students at local public schools. Any indirect increase in school enrollment associated with on-site job generation would be mitigated through implementation of applicable developer school impact fees. Impacts to schools are considered Class III, *less than significant.* | The City is strictly limited in the mitigation measures it may impose against developers of residential projects to address school crowding issues. The presumption of State law is that the developer's payment of school impact fees to the local school district, in an amount established by the school districts, would address school capacity impacts. | Less than significant. |
| **Impact PS-5** The proposed project would not directly generate demand for library services. Impacts to libraries would be Class III, *less than significant.* | None required other than payment of standard library fees by future residential developers. | Less than significant. |
| ***PUBLIC UTILITIES*** | | |
| **Impact PU-1** Development of the project would generate demand for an estimated 386 acre-feet of water per year. Although the Newhall County Water District would be able to supply the projected demand, impacts to water supply are considered Class II, *significant but mitigable* because of ongoing concerns about regional water supplies. | **PU-1(a)** Interior water conservation measures, as required by the State of California, shall be incorporated into the project. These include, but are not limited to:<br><br>• Installation of low flow toilets and urinals in all new construction.<br>• Installation of a water heating system and pipe insulation in all new construction to reduce water used before water reaches equipment or fixtures<br>• Installation of self-closing faucets in all lavatories | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | **PU-1(b)** Exterior water conservation features as recommended by the State Department of Water Resources, shall be incorporated into the project. These include, but are not limited to:<br>• Landscaping of common areas with low water-using plants<br>• Minimizing the use of turf by limiting it to lawn dependent uses<br>• Wherever turf is used, installing warm season grasses<br><br>**PU-1(c)** The project shall, to the extent feasible, use reclaimed water for irrigation of landscaping.<br><br>**PU-1(d)** Landscaped areas shall use vegetation that will eventually naturalize and require minimal irrigation. | |
| **Impact PU-2** Project implementation could potentially affect the existing MWD Foothill Feeder Newhall Tunnel pipeline, which traverses the central portion of the site. Conflicts with MWD right-of-way that could result in an interruption of MWD service or facilities would be considered a Class II, *significant but mitigable,* impact. | **PU-2** During project construction and throughout project operations, the applicant and future occupants shall comply with all requirements of the MWD's "Guidelines for Developments in the Area of Facilities, Fee Properties, and/or Easements of the Metropolitan Water District of Southern California." Per these guidelines, the applicant shall identify on-site MWD facilities on all applicable project maps and plans. The project applicant and/or future occupants shall obtain approval from MWD for all landscaping, structures, or other facilities within the MWD pipeline easement. | Less than significant. |
| **Impact PU-3** Buildout of the proposed project would generate an estimated 0.276 million gallons of wastewater per day. Because the wastewater treatment plants serving the site have adequate capacity to accommodate this amount of wastewater, this impact is considered Class III, *less than significant.* | No mitigation is required. The project site would need to be annexed into District No. 32 so that the LACSD may provide sewage treatment services to the proposed project. In addition, the District's Sphere of Influence would need to be amended to include the project site, and the project applicant would be required to pay the applicable fee for this amendment. | Less than significant. |
| **Impact PU-4** The local wastewater conveyance system is anticipated to be adequate to accommodate project-generated wastewater. Therefore, the impact to the wastewater conveyance system is considered Class III, *less than significant.* | No mitigation is required. The project applicant would be required to pay wastewater conveyance connection fees to the County Sanitation Districts. The connection fee is required so that necessary expansions to the sewage collection system can accommodate new development. In addition, the plans for the necessary pumping station and sewer collection infrastructure will need to be reviewed by Los Angeles County Public Works and approved by the Sanitation Districts and the City of Santa Clarita. | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | | |
| **Impact PU-5** The proposed project would consume an estimated 107 million kilowatt-hours per year. SCE indicates that it anticipates being able to serve the proposed development; therefore, impacts are considered Class III, *less than significant.* | No mitigation measures are required. The proposed project would be required to comply with energy efficiency standards of California Administrative Code Title 24. To comply with these requirements, the proposed project may include energy conservation measures such as incorporating specialized glass to reduce heating/cooling loads, installing insulation, or using ventilation devices to reduce the demand on heating/cooling systems. | Less than significant. |
| **Impact PU-6** The proposed project would consume an estimated 292 million cubic feet of natural gas per year. Southern California Gas Company could provide service to the project site; therefore, impacts are considered Class III, less than significant. | No mitigation measures are required. Per state and local energy guideline requirements, the proposed project will be required to meet the Energy Building Regulations adopted by the California Energy Commission (Title 24). Meeting these standards would conserve non-renewable natural resources to levels acceptable to the State of California. | Less than significant. |
| **Impact PU-7** The proposed project would generate about 29.1 tons of solid waste per day. Participation in Citywide and Countywide waste reduction efforts would reduce waste sent to area landfills to just under 15 tons per day. Because existing landfills serving the City have adequate capacity to accommodate project-generated waste, impacts related to solid waste are considered Class III, *less than significant.* | **PU-7(a)** Construction contractors shall provide recycling bins for glass, metals, paper, wood, plastic, green wastes, and cardboard during construction.<br><br>**PU-7(b)** Building materials shall be made of recycled materials, to the greatest extent possible.<br><br>**PU-7(c)** Reduce yard waste on the project site through the use of xeriscape techniques and the use of drought-tolerant and native vegetation in common area landscaping wherever possible.<br><br>**PU-7(d)** Business park tenants shall receive educational material on the City's waste management efforts. | Less than significant. |
| ***AESTHETICS*** | | |
| **Impact AES-1** The proposed project would alter scenic views from public viewing locations and alter City-designated Primary and Secondary ridgelines. This is considered a Class I, *unavoidably significant* impact. | **AES-1** The proposed water tanks shall be fully screened from public view with landscape material. | Unavoidably significant. |
| **Impact AES-2** The proposed project would produce new sources of light and glare that would extend the area of daytime glare and night light across the currently vacant property, which would alter the nighttime sky. Light and glare impacts are considered Class II, *significant but mitigable.* | **AES-2(a)** Prior to development, proposed lighting shall be indicated on site plans that demonstrate that spill-over of lighting would not affect surrounding areas. The lighting plan shall incorporate lighting that directs light pools downward or otherwise shield adjacent areas from glare. Light fixtures that shield excessive brightness at night shall be included in the | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | lighting plan. Non-glare lighting shall be used.<br><br>**AES-2(b)** All lighting of the landscaped areas shall be of an accent nature. Any security lighting shall be screened such that lighting globes are not visible from a distance of more than 20 feet.<br><br>**AES-2(c)** All on-site street lighting shall use cutoff luminaires. This would avoid creating high levels of glare and light pollution for motorists.<br><br>**AES-2(d)** Project design and architectural treatments shall incorporate additional techniques to reduce light and glare, such as use of low reflectivity glass, subdued colors for building materials in high visibility areas, and the use of plant material along the perimeter of the structures to soften views. | |
| **Impact AES-3** Project development may include structures and facilities that could be found to be inconsistent with the goals and policies of the City General Plan Community Design Element. | **AES-3** Specific designs of future all on-site development shall adhere to all applicable standards and guidelines of the *Ridgeline Preservation and Hillside Development Ordinance* and the Community Design Element of the General Plan to the satisfaction of the Director of Planning and Building Services. | Compliance with City-adopted standards, guidelines, goals, and policies would ensure that proposed landscaping and structures result in a high quality aesthetic environment that is generally compatible with the surrounding area. |
| **Impact AES-4** Some of the topographic modifications could be considered in conflict with the City's *Ridgeline Preservation and Hillside Development Ordinance*. A determination that the project is consistent with the requirements of the Ordinance would be required for project approval. | Measures BIO-4(a) and BIO-4(b) in Section 4.6, *Biological Resources*, would mitigate oak tree impacts to the degree feasible through development and implementation of an oak tree replacement program that As discussed in Section 4.1, *Land Use*, in order for the project to be approved, the City Planning Commission would need to make the following findings relative to the City's Ridgeline Preservation and Hillside Development Ordinance and Guidelines:<br><br>• The proposed use is proper in relation to adjacent uses, the development of the community and the various goals and policies of the General Plan.<br>• The use or development will not be materially detrimental to the visual character of the neighborhood or community, nor will it endanger the public health, safety or general welfare.<br>• The appearance of the use or development will not be different than the appearance of adjoining ridgeline | The City Planning Commission would need to make the findings discussed above in order to approve the project as proposed. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | areas so as to cause depreciation of the ridgeline appearance in the vicinity.<br>• The establishment of the proposed use or development will not impede the normal and orderly development and improvement of surrounding property, nor encourage inappropriate encroachments to the ridgeline area.<br>• It has been demonstrated that the proposed use or development will not violate the visual integrity of the significant ridgeline area through precise illustration and depiction. | |
| ***CULTURAL RESOURCES*** | | |
| **Impact CR-1** The proposed project would not disturb any known archaeological resources; however, site development has the potential to disturb as-yet undetected areas of prehistoric archaeological significance. This is considered a Class II, *significant but mitigable*, impact. | **CR-1(a)** Should unanticipated cultural resource remains be encountered during construction or land modification activities, the applicable procedures established by the Advisory Council on Historic Preservation concerning protection and preservation of Historic and Cultural Properties (36 CFR 8700) should be followed. In this event, work shall cease until the nature, extent, and possible significance of any cultural remains can be assessed and, if necessary, remediated. If remediation is needed, possible techniques include removal, documentation, or avoidance of the resource, depending upon the nature of the find.<br><br>**CR-1(b)** In the event that human remains are discovered during construction or land modification activities, the procedures in Section 7050.5 of the California Health and Safety Code shall be followed. These procedures require notification of the coroner and the Native American Heritage Commissions if the coroner determines the remains to be of Native American ancestry. | Less than significant. |
| **Impact CR-2** The proposed project would not directly affect any identified significant historic resources. However, possible indirect impacts to the Pioneer Oil Refinery are considered Class II, *significant but mitigable.* | **CR-2(a)** As provided in the Development Agreement, the applicant shall make a payment to the City which the City, at its discretion, may apply towards the construction of a new fence that will be effective in preventing unauthorized individuals from entering the Pioneer Oil Refinery site.<br><br>**CR-2(b)** Construction contractors shall take precautions to either avoid using heavy equipment in the vicinity of the acid tank on the Refinery property or stabilize the acid tank to prevent its collapse and potential destruction.<br><br>**CR-2(c)** The drainage system for the areas surrounding the Refinery shall be designed to | Less than significant. |

**Table ES-1 Summary of Environmental Impacts, Mitigation Measures, and Residual Impacts**

| Impact | Mitigation Measures | Significance After Mitigation |
|---|---|---|
| | prevent any further deposition of materials onto the Refinery site. | |
| ***RECREATION*** | | |
| **Impact REC-1** The project would remove existing informal trails on portions of the project site. However, these trails and recreational use of the project site are on private property and do not constitute public recreational resources. Therefore, this impact is considered Class III, *less than significant.* | None required. | Less than significant. |
| **Impact REC-2** The proposed industrial park may create demand for daytime recreational facilities. However, it would not directly generate additional resident population and therefore would not conflict with City park standards. In addition, the project would provide additional recreational amenities on-site. The impact relating to demand for recreation is considered Class III, *less than significant.* | None required. | Less than significant. |
| **Impact REC-3** The proposed project would provide a trail system that appears to generally meet City standards. This is considered a Class III, *less than significant* impact. | Although the proposed trail system appears to generally meet the intent of City policies relating to provision of trails, the following measures are recommended to maximize the utility of the system and minimize the potential for safety conflicts.<br><br>**REC-3(a)** The on-site trail system should provide a direct connection to William S. Hart Park. The applicant shall coordinate with the County of Los Angeles to determine the most appropriate location for such a connection.<br><br>**REC-3(b)** All trail crossings of internal roadways shall be appropriately signed and/or striped to alert drivers to the presence of a crossing.<br><br>**REC-3(c)** Trail easements for areas going through or across manufactured slopes or outside of road rights-of-way shall be included in the trail plan.<br><br>**REC-3(d)** A water meter for City use shall be included onsite.<br><br>**REC-3(e)** Onsite trails shall include safety fencing as required by the City Parks Department. | Less than significant. |

# Attachment 23-D

# TOPICAL RESPONSE 1: CLWA'S 41,000 AFY WATER TRANSFER

California Water Impact Network (C-WIN) and Friends of the Santa Clara River (Friends) have submitted comments on the Draft Additional Analysis for the Gate-King Industrial Park project, claiming that the Additional Analysis should not include or rely on the transfer in 1999 to Castaic Lake Water Agency (CLWA) of 41,000 acre-feet per year (afy) of State Water Project (SWP) Table A water supplies (hereafter referred to as "41,000 afy water transfer"). They assert that the Additional Analysis should not include or rely on CLWA's 41,000 afy water transfer because it is the subject of litigation and on that basis they claim it is not "final."

In addition, C-WIN states that the 41,000 afy water transfer is "further compromised" by recent court decisions concerning regional water supplies. It is asserted that these litigation challenges create uncertainty regarding the availability and reliability of water supplies for the Santa Clarita Valley. Please refer to **Topical Response 2: Litigation Concerning Water Supplies**, which discloses various litigation matters concerning water supplies, summarizes the status of such litigation, and explains why the City of Santa Clarita (City) concurs with conclusions reached by the expert water agencies, CLWA, Newhall County Water District (NCWD), Valencia Water Company, and Santa Clarita Water, a Division of CLWA (SCWD), that it is appropriate to include the 41,000 afy water transfer as part of CLWA's available SWP water supplies for planning purposes.

For the reasons discussed below, the City has determined that it is appropriate for the Gate-King Industrial Park Additional Analysis to rely on CLWA's SWP water supplies, including the 41,000 afy water transfer.

## 1. SWP OVERVIEW

As stated in the Gate-King Industrial Park Additional Analysis, from 1951 through 1959, the California Legislature authorized and funded construction of the SWP facilities, which are managed and operated by the California Department of Water Resources (DWR). SWP water supplies are used for both urban and agricultural uses throughout California.[1] The SWP facilities consist of a complex system of dams, reservoirs, power plants, pumping plants, canals, and aqueducts to deliver water throughout California.

At the inception of the SWP, DWR entered into individual water supply contracts with agricultural and urban water suppliers (SWP contractors). The contracts were the method used to fund construction and operation of the SWP facilities for the delivery of water to the SWP contractors. Each such contract sets forth the annual amount of water to which a SWP contractor is contractually entitled, which is stated in

1 Urban water uses also are referred to as "municipal and industrial," or "M&I," uses.

"Table A" to the contract (Table A Amount or allocation). However, the amount of SWP water actually available for delivery in any year may be an amount less than the contractor's maximum Table A amount due to hydrology, operational constraints, environmental constraints, and a number of other factors. The Table A Amount was previously referred to as "SWP entitlement."[2]

There are currently 29 SWP contractors that have entered into water supply contracts with DWR. A SWP contractor may annually request that DWR deliver water in the following year in any amount up to the SWP contractor's Table A Amount. The SWP contracts provide that in a year when DWR is unable to deliver the full amount of contractor requests, deliveries to contractors are reduced so that total deliveries equal total available supply for that year. CLWA's annual contractual Table A Amount is 95,200 afy. In the fall of each year, CLWA, along with all the other SWP contractors, submits a request to DWR for an allocation for the following year. DWR utilizes the factors noted above to "allocate" water among all contractors who have made requests, so that each contractor receives a percentage of its Table A Amount.

For example, if the SWP allocation is 40 percent of the Table A Amounts, each contractor receives 40 percent of its Table A Amount. If the allocation is 100 percent (as in 2006), each SWP contractor could receive the entire contractual Table A Amount. Therefore, CLWA's annual allocation is based on its total contractual Amount. **Table 1** indicates the actual Table A allocations made through the SWP since 1978.

The 41,000 afy water transfer amount is not kept "separate" as some have suggested. Since 2000, DWR has been including the 41,000 afy in the Table A Amount that is allocated in all allocations made to CLWA (based on its total annual allocation of 95,200 acre-feet). DWR has been *delivering* and the CLWA service area *receiving* water supply, including a percentage of the 41,000 afy, since calendar year 2000. While SWP contractors that receive water from the Delta currently hold Table A Amounts totaling approximately 4.13 million afy, the amount of Table A water actually delivered by the SWP may be less in some years due to hydrology, and operational and environmental constraints. Given existing SWP facilities, hydrology, operational and environmental conditions, and SWP contractor demands, the SWP is available to meet 100 percent of the SWP contractors' Table A requests this year (2006).[3] This 100

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2 As stated by the Court of Appeal in *Santa Clarita Organization for Planning the Environment v. County of Los Angeles* (2003) 106 Cal.App.4th 715, SWP Table A "entitlements" *are not equivalent to actual deliveries of water* because the amount of SWP water actually available for delivery in any given year may be an amount less than the Table A Amount. For example, the amount of SWP water actually available for delivery in any given year may be *reduced* due to several factors, including drought periods, increased SWP operational constraints, environmental water requirements/constraints (e.g., the listing of several fish species as endangered or threatened), water quality concerns, and other factors.

3 See, DWR *"News for Immediate Release,"* dated April 18, 2006, which is found in **Appendix J** of the Final Additional Analysis.

percent allocation of the Table A Amount to SWP contractors would add up to 4.13 million afy, distributed among the SWP contractors.[4]

**Table 1**
**Actual SWP Annual Allocations**

| Year | Percent Allocation | |
|---|---|---|
| | To Agricultural Contractors | To Urban (M&I) Contractors |
| 1978 to 1989 | 100 | 100 |
| 1990 | 50 | 100 |
| 1991 | 0 | 30 |
| 1992 | 45 | 45 |
| 1993 | 100 | 100 |
| 1994 | 50 | 50 |
| 1995 | 100 | 100 |
| 1996 | 100 | 100 |
| 1997 | 100 | 100 |
| 1998 | 100 | 100 |
| 1999 | 100 | 100 |
| 2000 | 90 | 90 |
| 2001 | 39 | 39 |
| 2002 | 70 | 70 |
| 2003 | 90 | 90 |
| 2004 | 65 | 65 |
| 2005 | 90 | 90 |
| 2006 | 100 | 100 |

*Source: California Department of Water Resources, State Water Project Analysis Office, 2006.*

This available supply varies from year to year. For example, in 2003, DWR approved deliveries of Table A Amount allocations, totaling 3.71 million acre-feet (or 90 percent of the 4.13 million acre-foot Table A Amount).[5] In 2002, DWR approved deliveries of Table A Amounts, totaling 2.89 million acre-feet (70 percent).[6] In 2001, DWR approved deliveries of Table A Amounts, totaling 1.61 million acre-feet (39 percent),[7] and in 2000, DWR approved deliveries of Table A Amounts, totaling 3.42 million acre-feet (90 percent).[8]

4 The original long-term water supply contracts between DWR and the SWP contractors assumed maximum annual Table A water deliveries of 4.23 million afy, assuming full development of the SWP. Currently, the maximum Table A Amounts for the SWP contractors that receive their supply from the Delta total approximately 4.13 million afy. (See, Final Additional Analysis, **Appendix AQ** [*SWP Delivery Reliability Report*, Public Review Draft, November 16, 2005, p. 7].)

5 See, DWR Bulletin 132-04, *Management of the California State Water Project*, September 2005, excerpts of which are provided in **Appendix O** of the Final Additional Analysis.

6 See, DWR Bulletin 132-03, December 2004 (**Appendix N** of the Final Additional Analysis).

7 See, DWR Bulletin 132-02, January 2004 (**Appendix M** of the Final Additional Analysis).

8 See, DWR Bulletin 132-01, December 2002 (**Appendix L** of the Final Additional Analysis).

The original plan for the SWP included constructing additional water storage and conveyance facilities as SWP contractor demands increased; however, very little new construction of SWP storage facilities has occurred since the SWP facilities were initially completed, and those facilities were never fully completed as contemplated in the 1950s. Although future construction or other actions could improve the quantity and reliability of SWP supplies, those actions would entail their own environmental reviews, potential litigation delays, and multi-year constructions periods.

## 2. CLWA'S 41,000 AFY WATER TRANSFER ACQUISITION

In 1999, CLWA purchased 41,000 afy of SWP Table A Amount from Kern County Water Agency (KCWA), acting on behalf of its member district, Wheeler Ridge-Maricopa Water Storage District. This purchase brought CLWA's total annual SWP Table A Amount to 95,200 afy; that purchase is generally referred to as the 41,000 afy water transfer.

The 41,000 afy water transfer was memorialized in a DWR/CLWA water supply contract amendment (Amendment No. 18), which reflects the *increase* in CLWA's annual allocation of SWP Table A Amounts from 54,200 afy to 95,200 afy. This increase reflects the permanent allocation of the 41,000 afy to CLWA (95,200 - 54,200 = 41,000).[9] As reported in the Gate-King Industrial Park Additional Analysis, the 41,000 afy water transfer has been completed, CLWA paid approximately $47 million for the additional Table A Amount, the monies have been delivered, the sales price has been financed through CLWA by tax-exempt bonds, and DWR increased CLWA's SWP Table A allocation, starting in calendar year 2000, because it was a permanent transfer/reallocation of SWP Table A water between SWP contractors.

Some comments have suggested that CLWA's 41,000 afy water transfer has not been approved by DWR. This is not correct. The 41,000 afy water transfer was approved by DWR on March 31, 1999, in the fully-executed amendment to CLWA's water supply contract (Amendment No. 18). Other comments have asserted that the 41,000 afy water transfer was not a "permanent" transfer of SWP Table A water. This also is incorrect. As stated by DWR in Bulletin 132-00, dated December 2001, at page 94, Amendment No. 18 "provided for the *permanent* transfer of 41,000 afy of SWP agricultural entitlement by CLWA from KCWA, . . . The transfer is consistent with implementation of the Monterey Amendment, which provides for the *permanent* transfer of up to 130,000 afy of agricultural entitlement to urban agencies." (Emphasis

9 A copy of "Amendment No. 18 to the Water Supply Contract between the State of California, Department of Water Resources and Castaic Lake Water Agency," dated March 31, 1999, is presented in **Appendix A** of the Final Additional Analysis.

added.) Importantly, since 2000, DWR has included the 41,000 afy in all allocations made to CLWA, based on CLWA's total annual Table A allocation of 95,200 acre-feet.[10]

To further support the fact that CLWA's 41,000 afy water transfer was a "permanent" transfer/ reallocation of SWP Table A Amount from one SWP contractor to another, in Bulletin 132-04 (September 2005), at page 120, DWR identified all eight Table A transfers, including the 41,000 afy water transfer, as "permanent" transfers under the Monterey Amendments. Furthermore, DWR has confirmed that the parties to the Monterey Settlement Agreement "recognize that the Kern-Castaic Lake Water Agency 41,000 afy Table A transfer is subject to pending litigation and agree that jurisdiction with respect to that litigation remain[s] in the Los Angeles County Superior Court and that nothing in the [Monterey Settlement Agreement] is intended to predispose the remedies or other actions that may occur in the pending litigation." In that same Bulletin, at page 120, DWR has also pointed out that the potential environmental effects of all eight "permanent Table A transfers" under the Monterey Amendments, including the 41,000 afy water transfer, will be analyzed in DWR's new Monterey EIR.[11] (The Monterey Amendments and related Monterey Settlement Agreement are discussed in further detail below). Thus, there is no basis to distinguish the 41,000 afy transfer and the other permanent Table A transfer, except for the California Environmental Quality Act (CEQA) litigation discussed in **Section 6**.

## 3. MONTEREY AMENDMENTS

In 1994, disputes arose between DWR and many agricultural and urban SWP contractors regarding the availability and distribution of water through SWP facilities. To avoid potential litigation, those parties met in Monterey, California, to attempt to resolve their ongoing disputes and, after negotiations, they agreed to a statement of principles, which became known as the "Monterey Agreement." The Monterey Agreement, signed by DWR and many of the agricultural and urban SWP contractors, established principles to be incorporated into contract amendments (the "Monterey Amendments"), which were primarily intended to increase the reliability of all SWP water supplies, stabilize SWP's rate structure, and increase water management flexibility for all SWP contractors. To date, all but two SWP contractors have accepted the Monterey Amendments. The Monterey Amendments included, among other benefits, water transfers among SWP contractors. Specifically, under the Monterey Amendments, SWP contractors may transfer unneeded Table A water to other contractors on a permanent basis, which provides financial relief from SWP charges for the seller and additional water supplies for the buyer. The Monterey

10 Please see **Appendix R** through **X** of the Final Additional Analysis for DWR's "Notices to State Water Project Contractors," informing them of increases or decreases in approved Table A Amounts from 2000 to 2006. In the 2006 Notice, CLWA's Table A allocation is shown as 95,200 afy, and in all of the prior Notices, CLWA's Table A allocation is shown in two places, once under the "San Joaquin Valley" heading, which shows the allocation at 12,700 afy, and again under the "Southern California" heading, which shows the allocation at 82,500 afy, totaling 95,200 afy.

11 See, DWR Bulletin 132-04 (September 2005), p. 120 (**Appendix O** of the Final Additional Analysis).

Amendments have facilitated the transfer of 130,000 afy of SWP Table A Amounts from agricultural to urban SWP contractors.[12] Many such transfers were implemented soon after the Monterey Amendments became effective. CLWA's 41,000 afy water transfer was one of the water transfers effected by the Monterey Amendments.

## 4. ENVIRONMENTAL REVIEW OF MONTEREY AMENDMENTS AND SUBSEQUENT LITIGATION

A Program EIR was prepared and certified to analyze the environmental effects of implementing the Monterey Agreement/Monterey Amendments. The adequacy of the Program EIR was challenged in litigation filed in 1995 in the Sacramento County Superior Court, and the Superior Court upheld the adequacy of the Program EIR. Before and after the Sacramento County trial court's decision, DWR and the agricultural and urban SWP contractors who had executed the Monterey Agreement began implementing various amendment provisions, including the completion of permanent transfers of Table A Amounts among agricultural and urban SWP contractors. Again, CLWA's 41,000 afy water transfer was one of eight water transfers effectuated by the Monterey Amendments. The trial court's decision was subsequently appealed. On appeal, the petitioners sought an injunction to prevent further implementation of the Monterey Agreement during the appeal. However, the appellate court denied the requested injunction.

The appellate court ultimately reversed the trial court's decision. The appellate court held that the Program EIR was improperly prepared by the Central Coast Water Agency, as "Lead Agency" under CEQA, rather than by DWR, which should have been the "Lead Agency." The appellate court also found that the EIR did not sufficiently discuss implementation of a "no project" alternative, and concluded that a new EIR must be prepared and certified.

The appellate court then remanded the case to the Sacramento County trial court and directed that the trial court issue a writ of mandate vacating certification of the EIR and retaining jurisdiction until DWR, as lead agency, prepared and certified an EIR in accordance with CEQA. The appellate court further directed that the trial court consider whether the Monterey Amendments may continue to be

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12 Neither the Monterey Agreement nor the Monterey Amendments created a new right to carry out permanent transfers of SWP Table A Amounts. That right had existed since the early 1960s through Article 41 of the SWP contracts. The Monterey Amendments simply provided a vehicle through which the SWP agricultural contractors promised that they would support such Article 41 transfers up to 130,000 acre feet. The Monterey Amendments also did not limit the SWP contractors' rights to implement permanent transfers under existing law other than those described in the Monterey Amendments. (See, e.g., Water Code §§382, 383.)

implemented while the new EIR is being prepared. (*Planning & Conservation League v. Department of Water Resources* (2000) 83 Cal.App.4th 892.)[13]

The appellate court decision invalidated certification of the Program EIR, but did not set aside, invalidate or otherwise vacate the Monterey Amendments or enjoin the water transfers effected thereunder. Instead, the appellate court directed the trial court to consider under CEQA whether the Monterey Amendments should remain in place pending DWR's preparation of a new EIR, and to retain jurisdiction pending certification of that EIR. In addition, no court orders have ever been issued to "stay" further implementation of the Monterey Amendments.

## 5. THE MONTEREY SETTLEMENT AGREEMENT

In March 2001, before the Sacramento County trial court had acted on remand, the parties to the *PCL* litigation entered into settlement negotiations. In May 2003, DWR, Central Coast Water Authority, Planning and Conservation League, certain SWP contractors (including CLWA) and other entities entered into a final settlement of the *PCL* litigation (the "Monterey Settlement Agreement").[14] Under the Monterey Settlement Agreement, the parties expressly agreed that the SWP would continue to be administered and operated in accordance with both the Monterey Amendments and terms of the Monterey Settlement Agreement:

> *"Pending the Superior Court's issuance of an order discharging the writ of mandate in the underlying litigation, the Parties will jointly request that the Superior Court enter an order approving this Settlement Agreement, and an order, pursuant to California Public Resources Code Section 21168.9, authorizing on an interim basis the administration and operation of the SWP . . . in accordance with the Monterey Amendments, [and] the terms of this Settlement Agreement. ..." (Final Additional Analysis,* ***Appendix AF*** *[Monterey Settlement Agreement, p. 9].)*

The Monterey Settlement Agreement did not set aside, invalidate, or otherwise vacate the Monterey Amendments, or any of the water transfers effectuated under the Monterey Amendments. On June 6, 2003, the Sacramento County Superior Court issued the requested order, pursuant to CEQA (Pub.Res.Code Section 21168.9), approving both the Monterey Settlement Agreement and the administration and operation of the SWP pursuant to the Monterey Amendments and the terms of the approved agreement.[15]

Section III(C)(4) of the Monterey Settlement Agreement required DWR to carry-out an "[a]nalysis of the potential environmental effects relating to" eight water transfers under the Monterey Amendments,

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13 The decision, *Planning and Conservation League v. Department of Water Resources* (2000) 83 Cal.App.4th 892, hereafter referred to as "*PCL*," is presented in **Appendix AI** of the Final Additional Analysis.

14 The Monterey Settlement Agreement is presented in **Appendix AF** of the Final Additional Analysis.

15 The Sacramento County trial court's Order is presented in **Appendix AR** of the Final Additional Analysis.

seven so-called "Attachment E Transfers" and the 41,000 afy water transfer, also referred to in the agreement as the "Kern-Castaic Transfer." Further, the Monterey Settlement Agreement obligated DWR to evaluate all eight of the water transfers in the same manner, even though seven of them, defined in the agreement as the "Attachment E Transfers," were no longer subject to legal challenge. (See, Final Additional Analysis, **Appendix AF** [Monterey Settlement Agreement, Sections III(C)(4), III(D), III(E), pp. 11-12].) The point of the DWR review of the eight transfers was not to determine whether to continue the transfers, because seven of them beyond CEQA challenge, and the eighth, the 41,000 afy transfer, was also a permanent transfer, but it was still subject to litigation. Rather, the point of the DWR review of all eight transfers was to examine the environmental effects of such transfers in light of the Monterey Agreement as a whole.

In fact, Section III(D) of the Monterey Settlement Agreement affirmed that none of the parties could challenge the effectiveness or validity of the Attachment E Transfers, which had been litigated in other forums or had become final without challenge by the expiration of applicable statutes of limitations. According to CLWA and other signatories to the Agreement, this is why Section III(D) referred to the Attachment E Transfers as "final." (See, Final Additional Analysis, **Appendix AF** [Monterey Settlement Agreement, Section III(D), p. 12].) The 41,000 afy water transfer was not included among the Attachment E transfers, only because the 41,000 afy water transfer was then under the jurisdiction of the Los Angeles County Superior Court and that litigation was ongoing.[16]

Section III(E) protects the jurisdiction of the Los Angeles County Superior Court in connection with the then-pending CEQA litigation challenging the validity of CLWA's EIR on the 41,000 afy water transfer. Section III(E) states, in part: "nothing in this Settlement Agreement is intended to predispose the remedies or other actions that may occur in that pending litigation." As set forth below, Section III(E) provides:

> "*Acknowledgement and Agreement Regarding Kern-Castaic Transfer [the 41,000 afy water transfer]. With respect to Section III(C)(4)(b) regarding the Kern-Castaic Transfer, the Parties* recognize that such water transfer is subject to pending litigation in the Los Angeles County Superior Court *following remand from the Second District Court of Appeal. (See* Friends of the Santa Clara River v. Castaic Lake Water Agency, *95 Cal.App.4th 1373, 116 Cal.Rptr.2d 54 (2002);* review denied *April 17, 2002.) The Parties agree that* jurisdiction *with respect to that litigation should* remain *in that court and that* nothing in this Settlement Agreement is intended to predispose the remedies or other actions that may occur in that pending litigation." (Emphasis added.) *(Final Additional Analysis,* ***Appendix AF*** *[Monterey Settlement Agreement, Section III(E), p. 12].)*

16 In Section VII(I), the parties further agreed that, should the certification of DWR's new EIR be challenged, the challenging parties must stipulate to the continued administration and operation of the SWP during the pendency of that challenge, and, should that challenge be successful, during any future challenges to future DWR EIR's. In turn, Section VII(I), subdivision (1), limits the grounds on which DWR's return to the writ of mandate can be legally challenged, and Section VII(J) prohibits any future litigation challenging the validity of any Monterey Amendments (or any portions thereof). Finally, Sections VII(L) and IX provide that all disputes regarding the Monterey Settlement Agreement must be mediated.

The Monterey Settlement Agreement does not preclude CLWA, a signatory to that agreement, from using the 41,000 afy water transfer as part of its overall SWP Table A supplies for planning purposes. First, the language of the Monterey Settlement Agreement, quoted above, does not state that CLWA may not rely on the 41,000 afy water transfer (also referred to as the Kern-Castaic transfer). Second, nothing in the Monterey Settlement Agreement precludes a project EIR from referencing and using all of CLWA's SWP Table A supplies in analyzing available water supplies for the Santa Clarita Valley. Given that the 41,000 afy water transfer was specifically covered by the Monterey Settlement Agreement, if the parties to that agreement had intended to preclude reliance on the 41,000 afy water transfer, they surely could and would have spelled out that prohibition. Rather than prohibiting CLWA or others from relying on the 41,000 afy water transfer, the Monterey Settlement Agreement simply clarified that the transfer was (and remains today) under the jurisdiction of the Los Angeles County Superior Court.

In addition, the Monterey Settlement Agreement allows implementation of the Monterey Amendments and validates the water transfers that already had taken place by the time that agreement took effect. The only reason the 41,000 afy water transfer was not included on the list of "final" transfers in Attachment E for purpose of that agreement was that it was the subject of ongoing litigation. The 41,000 afy water transfer was both a permanent and final reallocation of SWP Table A Amounts from one SWP contractor to another (CLWA), just as were the other seven transfers; the pending 41,000 afy water transfer litigation did not convert that transfer from permanent to temporary.

Importantly, DWR, itself, includes the 41,000 afy to CLWA in its published "Notices to State Water Project Contractors." For example, on April 18, 2006, DWR sent its notice to SWP contractors stating that DWR was increasing its allocation of 2006 SWP water to its contractors. The table attached to that Notice listed all such contractors' Table A Amounts, and their approved allocations. CLWA's Table A Amount is listed under the Southern California heading in the amount of 95,200 afy, which includes CLWA's 41,000 afy. If DWR, the agency that administers the SWP, did not consider CLWA's 41,000 afy water transfer to be both a permanent and final reallocation of SWP Table A Amounts, it would not publish CLWA's total Table A allocation at 95,200 afy.[17]

Contrary to comments received from C-WIN and Friends, which attempt to place a cloud over CLWA's reliance upon the 41,000 afy water transfer, the terms of the Monterey Settlement Agreement make clear that the agreement was intended to protect the Los Angeles County Superior Court's jurisdiction in the pending 41,000 afy water transfer litigation. Nothing in that agreement characterized the 41,000 afy water transfer as not final. And, nothing in that agreement prohibited any party, agency, or other entity from relying on the 41,000 afy water transfer for planning purposes.

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17 DWR's April 18, 2006, "Notice to State Water Project Contractors" is presented in **Appendix S** of the Final Additional Analysis.

## 6. CLWA ENVIRONMENTAL REVIEW OF 41,000 AFY WATER TRANSFER AND LITIGATION

Prior to completion of the 41,000 afy water transfer, the proposed transfer was the subject of environmental review by CLWA and KCWA and its member district. The agencies selling the 41,000 afy of SWP Table A Amount to CLWA assessed the environmental consequences of the proposed transfer within their service area in a Final EIR, dated June 1998. That EIR was certified in 1998 and was not challenged in court. As a result, that EIR is conclusively presumed to be valid (Pub. Res. Code §21167.2).

CLWA also prepared a supplemental Final EIR, which assessed the environmental effects of CLWA's acquisition of the 41,000 afy within its service area. The Board of Directors of CLWA certified the Supplemental Final EIR in March 1999. Thereafter, in April 1999, a lawsuit was brought in the Los Angeles County Superior Court challenging the adequacy of the EIR under CEQA (*Friends of the Santa Clara River, et al. v. Castaic Lake Water Agency, et al.*, Case No. BS 056954, also referred to as "*Friends*"). The Los Angeles County trial court in the *Friends* litigation ruled in favor of CLWA and upheld the adequacy of the EIR under CEQA.

In October 2000, the *Friends* petitioners filed an appeal. During the pendency of the *Friends* appeal, the Third District Court of Appeal issued the *PCL* decision, which found the Monterey EIR inadequate and ordered it decertified.[18] On appeal in *Friends*, the Second District Court of Appeal considered the *Friends* petitioners' multiple arguments, and concluded that CLWA's EIR on the 41,000 afy water transfer must be decertified, not because the EIR was substantially inadequate or failed to support the analysis of the transfer's approval, but only because it had been "tiered" from the Monterey EIR, recently found to be inadequate:

> *"We have examined all of appellant's other contentions and find them to be* without merit. *If the* PCL/*tiering problem had not arisen,* we would have affirmed the judgment."[19] (Emphasis added.)

Nonetheless, like the Third District Court of Appeal in the *PCL* decision, the Second District Court of Appeal in *Friends* refused to issue any ruling affecting CLWA's ability to continue to rely on the 41,000

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18 Please refer to **Appendix AI** of the Final Additional Analysis for the *PCL* decision.

19 The January 2002 *Friends* decision entitled, *Friends of the Santa Clara River v. Castaic Lake Water Agency* (2002) 95 Cal.App.4th 1373, is found in **Appendix AA** of the Final Additional Analysis. The *Friends* decision provides useful factual background information concerning the Monterey Amendments, the Monterey Amendments EIR, water transfers authorized by the Monterey Amendments, the local agency environmental review of the 41,000 afy water transfer, CLWA's acquisition of the 41,000 afy, and the relationship between the *PCL* decision and the *Friends* decision. See, Final Additional Analysis, **Appendix AA** [*Friends* decision, pp. 1376-1384].

afy water transfer, leaving it to the trial court's discretion whether or not to enjoin CLWA's use of the water pending its completion of a new EIR.[20]

In December 2002, on remand to the Los Angeles County Superior Court, the *Friends* petitioners sought to enjoin CLWA's use of, and reliance upon, the 41,000 afy water transfer under CEQA, but the trial court rejected that request. Specifically, the trial court maintained its jurisdiction over the matter and authorized CLWA to utilize any of the 41,000 afy subject to the following order:

> *"Respondent [CLWA] will not be prohibited from using the water to which it is entitled, but Petitioner may renew its application for such prohibition based upon evidence of the actual use of such additional water for purposes it considers improper."*[21]

The *Friends* petitioners never pursued the trial court's suggestion for them to "renew" their request to prohibit the use of the 41,000 afy water transfer "based upon evidence of the actual use of such additional water for purposes it considers improper." Instead, the *Friends* petitioners appealed the trial court's judgment and, again, requested that the use of the 41,000 afy water transfer be prohibited.

However, on December 1, 2003, in an unpublished decision, the Second District Court of Appeal affirmed the trial court's ruling allowing CLWA to utilize and rely on the 41,000 afy water transfer pending completion of its new EIR.[22] Significantly, petitioners and others in the *Friends II* decision argued that the trial court's determination of whether to enjoin CLWA's use of the 41,000 afy water transfer should be based on the status of the *PCL* litigation and DWR's new EIR for the Monterey Amendments the same argument they advance here. In making that argument, they relied on language in the original *Friends* decision in which the Court of Appeal suggested that *as one option* CLWA "may be able to cure the *PCL* problem by awaiting action by the DWR complying with the *PCL* decision, then issuing a subsequent EIR, supplement to EIR, or addendum to EIR . . . tiering upon a newly certified Monterey Agreement EIR."[23] The Court of Appeal in *Friends II*, however, rejected this argument, explaining:

> *"Amici misapprehend our directions to the trial court. As explained above, those directions are found in the dispositional language of our opinion. That language directed the trial court,* inter alia, *to "consider such orders it deems appropriate under [Pub.Res.Code] section 21168.9." [Citation.] That section grants the trial court broad powers to fashion equitable relief. [Note.]* Amici's argument that the exercise of said discretion was to be based upon the status of either the PCL litigation or the new EIR for the Monterey Agreement is at odds with the clear dispositional language we employed. *The two paragraphs in our opinion upon which* amici *rely were merely suggestions as to how respondent could proceed and a statement that, in exercising its discretion whether to grant equitable relief pending completion of a new EIR for this project, the trial court could ascertain, and if it so chose, rely upon the status of the PCL litigation*

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20 See, Final Additional Analysis, **Appendix AA** [*Friends* decision, p. 1388].

21 For the trial court's decision, please refer to **Appendix AA**, p. 2 ¶6, of the Final Additional Analysis.

22 For the Court of Appeal's unpublished opinion, please refer to **Appendix Y** of the Final Additional Analysis [*Friends of the Santa Clara River v. Castaic Lake Water Agency*, 2003 WL 22839353 (*Friends II*)].

23 Please see **Appendix Y** of the Final Additional Analysis (*Friends II*, p. 16).

*and new Monterey Agreement EIR."* (Emphasis added; *Final Additional Analysis, Appendix Y* [Friends II, *p. 17*].)

The Court of Appeal not only refused to enjoin the 41,000 afy water transfer, but also made it clear that CLWA's use of that water is not legally bound to either the *PCL* litigation or to DWR's new EIR for the Monterey Amendments.

Accordingly, neither the *PCL* litigation, the Monterey Settlement Agreement, nor the *Friends* or *Friends II* litigation has changed the status of the 41,000 afy water transfer from a permanent, final allocation of SWP Table A water to a "temporary or non-final" water transfer. To the contrary, the Monterey Settlement Agreement specifically provides that the SWP will continue to be administered and operated in accordance with both the Monterey Amendments and the terms of the Settlement Agreement, and the *Friends* trial court issued its Judgment permitting CLWA to continue to use the 41,000 afy, a decision that the Second District Court of Appeal affirmed. Thus, the two courts charged with responsibility over the 41,000 afy water transfer have determined that CLWA may continue to use the water to which it is entitled pending preparation of CLWA's new EIR.

Furthermore, CLWA completed and, on December 22, 2004, certified its new EIR on the 41,000 afy water transfer.[24] The CLWA 2004 EIR fully analyzed the environmental implications of the 41,000 afy water transfer without tiering from the Monterey EIR.[25] On December 30, 2004, CLWA lodged the certified Final EIR with the Los Angeles County Superior Court, as part of its "return" to the trial court's writ of mandate issued by the trial court as directed in the *Friends I* decision. There was no opposition filed to CLWA's return, which challenged the adequacy of CLWA's 1999 EIR on the 41,000 afy water transfer. On February 1, 2005, petitioner, Friends of the Santa Clara River, filed a request for entry of a dismissal with prejudice of the *Friends I* action, which was subsequently entered by the Los Angeles County Superior Court, terminating the *Friends I* action.

CLWA's 2004 EIR is currently the subject of two other legal challenges brought by C-WIN and Planning and Conservation League in January 2005. Despite the pending litigation, however, an EIR is presumed adequate under CEQA, and the plaintiff in a CEQA action has the burden of proving otherwise.[26] Because the CLWA 2004 EIR was overturned solely because it tiered from a later-decertified Monterey EIR and would otherwise have been affirmed, and because CLWA has now completed and certified the 2004 EIR approving the 41,000 afy water transfer without tiering from a Monterey EIR, the City has

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24 For a copy of CLWA Resolution No. 2354 certifying the Final EIR on the 41,000 afy transfer, and approving that project, please refer to **Appendix I** of the Final Additional Analysis.

25 CLWA's Draft and Final EIR (SCH No. 1998041127) for the 41,000 afy water transfer are incorporated by reference and available for public review and inspection at the City of Santa Clarita, 23920 Valencia Boulevard, Santa Clarita, California, Contact: Mr. Jason Mikaelian, AICP, (661) 255-4330.

26 See, e.g., Pub.Res.Code §21167.3(b), CEQA Guidelines §15231; *Barthelemy v. Chino Basin Water Dist.* (1995) 38 Cal.App.4th 1609, 1617.

determined, based on substantial evidence in the record as a whole, that it remains appropriate for the Gate-King Industrial Park Additional Analysis to include those water supplies in its water supply and demand analysis, while acknowledging and disclosing the potential uncertainty created by the pending litigation.

On a related matter, the City has noted that DWR submitted a comment letter on CLWA's 2004 EIR for the 41,000 afy water transfer project. In that letter, DWR stated that CLWA's 2004 EIR "adequately and thoroughly discusses the proposed project and its impacts."[27] DWR's letter specifically addressed DWR's new Monterey EIR and the relationship between that EIR and the CLWA 2004 EIR, stating:

> *"The DEIR provides a good discussion of the relationship between the 41,000 acre-feet Table A transfer and the current Monterey Plus [the new Monterey EIR] process. DWR will analyze the effects of all Table A transfers that were part of the Monterey Amendment to the SWP contracts [e.g., both the 41,000 afy and the Attachment E transfers] in the Monterey Plus EIR."* Id.

DWR's comment letter contains no statement or suggestion that the 41,000 afy water transfer is contingent on DWR's approval, or on DWR's new Monterey EIR, or is in any other way not permanent.

## 7. UNCERTAINTIES CONCERNING CLWA'S 41,000 AFY WATER TRANSFER

The comment letters argue that the pending litigation challenges to CLWA's 2004 EIR for the 41,000 afy transfer, and DWR's preparation of a new Monterey Agreement EIR, introduce an element of potential uncertainty regarding the 41,000 afy water transfer. The City has acknowledged and considered these potential uncertainties, and concluded that, based on a review of all the surrounding circumstances, these events do not significantly affect the reliability of the transfer amount. Therefore, the City has concluded that it is still appropriate to rely on the transfer amount as part of CLWA's 95,200 afy Table A Amount, for the reasons discussed below.

- First, the 41,000 afy water transfer was memorialized in 1999 in a DWR/CLWA water supply contract amendment, and DWR has allocated and annually delivered the water in accordance with the completed transfer since 2000. At the same time, DWR and KCWA executed Amendment No. 28 to the water supply contract between these parties, which also provided for the permanent transfer of the 41,000 afy by KCWA, acting on behalf of its member district, to CLWA, which DWR also stated was consistent with the implementation of the Monterey Amendments. Neither of these contract amendments was ever legally challenged, and both are considered permanent and in full force and effect. In connection with that transfer, CLWA paid approximately $47 million for the additional 41,000 afy Table A supply, the monies have been delivered, the sale price has been financed through the sale of CLWA tax-exempt bonds, and DWR has approved and amended CLWA's long-term water supply contract to reflect the increase in CLWA's SWP Table A Amount, and the permanent transfer and reallocation of SWP Table A supply between SWP contractors.

- Second, DWR has from its inception treated the 41,000 afy water transfer as a "permanent" Table A transfer from one SWP contractor to another, and has stated that the transfer is consistent with

27 For a copy of the DWR letter, dated July 30, 2004, commenting on CLWA's EIR for the 41,000 afy water transfer, please refer to **Appendix P** of the Final Additional Analysis.

implementation of the Monterey Amendments, which provide for the "permanent" transfer of up to 130,000 afy of agricultural Table A Amounts to urban SWP contractors.

- Third, the Court of Appeal held that the only defect in the 1999 CLWA EIR was that it tiered from the Monterey EIR, which was later decertified. This defect has now been remedied by CLWA's preparation in 2004 of a new EIR that did not tier from the Monterey EIR. CLWA's 2004 EIR is presumed adequate pending resolution of the latest legal challenges to that EIR.

- Fourth, the Monterey Settlement Agreement expressly authorized the operation of the SWP in accordance with the Monterey Amendments and the terms of the settlement agreement. The Monterey Amendments, which are still in effect, authorized SWP contractors to transfer unneeded SWP supply amounts to other contractors on a permanent basis. Specifically, the Monterey Agreement provisions authorized 130,000 afy of agricultural SWP contractors' entitlements to be available for sale to urban SWP contractors. CLWA's 41,000 afy acquisition was a part of the 130,000 afy of SWP Table A supply that was transferred, consistent with the Monterey Amendments. The 41,000 afy transfer was not listed on Attachment E to the Monterey Settlement Agreement with the other permanent transfers because it was the only permanent transfer that was subject to then pending litigation (i.e., the *Friends I* litigation). The Monterey Settlement Agreement otherwise treated all eight of the permanent transfers the same, and provided that DWR's new EIR would do so, as well, as DWR has affirmed in a letter commenting on the CLWA 2004 EIR for the 41,000 afy water transfer. No other transfers that were part of the 130,000 afy were the subject of litigation.

- Fifth, as to the new Monterey EIR, the Court of Appeal in the 41,000 afy litigation has stated that CLWA's use of the 41,000 afy is not legally bound to the *PCL* litigation, or to DWR's new Monterey EIR. In addition, DWR did not oppose CLWA's completion and certification of the EIR for the 41,000 afy water transfer, independent of DWR's new Monterey EIR. Thus, the pending legal challenges to the CLWA EIR, and DWR's preparation of a new Monterey EIR, should have no impact on the amount of SWP water available to CLWA as a result of the completed 41,000 afy water transfer.

- Sixth, two courts have refused to enjoin the 41,000 afy water transfer, pending CLWA's preparation of a new EIR, and this EIR is now completed and certified by CLWA as adequate and complete under CEQA. CLWA also filed the 2004 EIR on the 41,000 afy transfer with the Los Angeles County Superior Court as part of its "return" to the trial court's writ of mandate as directed in the *Friends I* decision. Thereafter, the petitioner voluntarily dismissed that action, resulting in its termination. As a result, both the CLWA 2004 EIR and the 41,000 afy water transfer are no longer subject to challenge in the *Friends I* action. This litigation finality brings further certainty to the permanent 41,000 afy water transfer.

- Seventh, as stated above, CLWA's amended water supply contract documenting the 41,000 afy water transfer remains in full force and effect, and no court has ever questioned the validity of the contract or enjoined the use of this portion of CLWA's SWP Table A Amount.

Other comments have stated that the Monterey Settlement Agreement requires that DWR's new Monterey EIR analyze, among others, the 41,000 afy water transfer; and, therefore, water from that transfer should not be relied upon until DWR completes its new EIR. The City does not concur with these comments.

First, nothing in either the Monterey Settlement Agreement or the related court orders preclude CLWA from using or relying upon the 41,000 afy water transfer, which remains intact pending completion of the DWR EIR. Second, nothing in the terms of the Monterey Settlement Agreement precludes CLWA from proceeding with its 2004 EIR to address the environmental implications of the 41,000 afy water transfer.

Again, if the Monterey Settlement Agreement had intended such a result, then it is reasonable to assume that provisions would have been included in that agreement making it clear that CLWA could not proceed with its own EIR on the 41,000 afy water transfer. In fact, no such provisions were included in the Monterey Settlement Agreement, because such provisions would have interfered with the jurisdiction of another court in the separately pending 41,000 afy water transfer litigation. Finally, although the Monterey Settlement Agreement requires the new Monterey EIR to analyze the potential environmental effects relating to CLWA's 41,000 afy water transfer as well as the other permanent transfers, it does not, and cannot, preclude CLWA from conducting its own environmental review of that transfer. Indeed, CLWA *was required* by court order to prepare a new EIR to address the environmental implications of the 41,000 afy water transfer.[28] In the meantime, however, there are no court orders precluding CLWA from using or relying on that water supply. And, as discussed below, CLWA already has completed and certified the 2004 EIR, which has addressed the environmental impacts of the 41,000 afy water transfer, without tiering or relying on the decertified 1995 Monterey EIR.

In short, CLWA's 2004 EIR provides the environmental analysis for the 41,000 afy water transfer, which is required by CEQA and the orders and opinions issued in the 41,000 afy water transfer litigation. Nothing in CEQA or any law, regulation, or agreement constrains or limits CLWA's discretion to proceed with its own EIR on the 41,000 afy water transfer.

For all these reasons, The City of Santa Clarita has determined that it remains appropriate to rely on the 41,000 afy water transfer as part of CLWA's SWP Table A water supplies. Furthermore, based on the above, the City has determined that it is reasonable to conclude that even if a court finds the CLWA 2004 EIR legally deficient, that court, like all others before it, will again refuse to enjoin the permanent 41,000 afy water transfer, and instead require further revisions to that EIR. Therefore, the pending legal challenges to the 41,000 afy water transfer should have no impact on the amount of SWP water available to CLWA as a result of the completed 41,000 afy water transfer.

## 8. OTHER LITIGATION CONCERNING THE 41,000 AFY TRANSFER

The CLWA 41,000 afy water transfer also has been the subject of two recent court decisions. The first court case involved a published appellate court decision in *California Oak Foundation v. City of Santa Clarita* (2005) 133 Cal.App.4th 1219. In the *California Oak Foundation* decision (the decision setting aside the first EIR for this project), the Court of Appeal invalidated an EIR under CEQA for the Gate-King project

28 In the Judgment granting the writ of mandate setting aside CLWA's certification of the 41,000 afy EIR, the trial court specifically retained "jurisdiction until respondent Castaic Lake Water Agency certifies an Environmental Impact Report that complies with the California Environmental Quality Act and is consistent with the views expressed by the Court of Appeal Opinion, filed January 10, 2002, Case No. B145283." (Final Additional Analysis, **Appendix AC** [Judgment Granting Peremptory Writ of Mandate, dated October 25, 2002, p. 2, ¶3].)

located in the City of Santa Clarita, because the EIR did not explain how demand for water would be met if the 41,000 afy water transfer were set aside, or, alternatively, why it is appropriate to rely on the 41,000 afy transfer in any event. The above analysis explains in detail why it is appropriate to rely on the 41,000 afy water transfer as part of CLWA's SWP water supplies. None of this information or analysis was contained in the Gate-King EIR. In short, the Gate-King Industrial Park Additional Analysis supplies the information supporting the decision to rely on the 41,000 afy transfer, which the *California Oaks* court indicated was needed. A copy of the *California Oak Foundation* decision is provided in Appendix 3.0-21 of the Draft Additional Analysis.

The second court case involved a separate legal challenge under CEQA to an EIR for the West Creek project, located in Los Angeles County. This separate legal challenge was brought in Santa Barbara County Superior Court in *Santa Clarita Organization for Planning the Environment v. County of Los Angeles*, Case No. 1043805 (*West Creek* litigation). After a hearing, the Santa Barbara County Superior Court issued an Order determining that the EIR prepared for the West Creek project contained substantial evidence in the record to support Los Angeles County's decision to rely on the 41,000 afy water transfer for planning purposes. The Order noted that substantial evidence appeared in the record to support the County's decision to rely on the 41,000 afy water transfer, while acknowledging and disclosing the potential uncertainties involving the 41,000 afy water transfer created by pending litigation. The Order summarized the evidence, including the fact that: (a) DWR continues to allocate and deliver the water in accordance with the amended water supply contract authorizing the 41,000 afy transfer; (b) neither the *PCL* litigation, nor the Monterey Settlement Agreement set aside any of the water transfers made under the Monterey Amendments, including the 41,000 afy water transfer; (c) the courts have not enjoined CLWA's use of the 41,000 afy water transfer; and (d) CLWA has prepared and certified a new EIR on the 41,000 afy water transfer and that EIR is presumed adequate despite pending legal challenges. A copy of the trial court Order in the *West Creek* litigation is provided in **Appendix AU** of this Additional Analysis. The *West Creek* decision is currently on appeal.

In conclusion, one of the primary purposes of this Additional Analysis topical response is to respond to public comments and to inform decision makers and the public of pending and related litigation concerning CLWA's 41,000 afy water transfer, so that the information can be taken into account in determining whether there is adequate water supply for the Gate-King Industrial Park project, in addition to existing and planned future uses in the Santa Clarita Valley. In making that informed decision, the law does not require a showing of freedom from all legal challenges for a source of water to be included in overall SWP water supplies. Based on the above information, the City has determined that CLWA's 41,000 afy water transfer is sufficiently certain, so that it is not only permissible, but also reasonable, to include the 41,000 afy in CLWA's water supply sources for the Santa Clarita Valley.

# TOPICAL RESPONSE 1: CLWA'S 41,000 AFY WATER TRANSFER

California Water Impact Network (C-WIN) and Friends of the Santa Clara River (Friends) have submitted comments on the Draft Additional Analysis for the Gate-King Industrial Park project, claiming that the Additional Analysis should not include or rely on the transfer in 1999 to Castaic Lake Water Agency (CLWA) of 41,000 acre-feet per year (afy) of State Water Project (SWP) Table A water supplies (hereafter referred to as "41,000 afy water transfer"). They assert that the Additional Analysis should not include or rely on CLWA's 41,000 afy water transfer because it is the subject of litigation and on that basis they claim it is not "final."

In addition, C-WIN states that the 41,000 afy water transfer is "further compromised" by recent court decisions concerning regional water supplies. It is asserted that these litigation challenges create uncertainty regarding the availability and reliability of water supplies for the Santa Clarita Valley. Please refer to **Topical Response 2: Litigation Concerning Water Supplies**, which discloses various litigation matters concerning water supplies, summarizes the status of such litigation, and explains why the City of Santa Clarita (City) concurs with conclusions reached by the expert water agencies, CLWA, Newhall County Water District (NCWD), Valencia Water Company, and Santa Clarita Water, a Division of CLWA (SCWD), that it is appropriate to include the 41,000 afy water transfer as part of CLWA's available SWP water supplies for planning purposes.

For the reasons discussed below, the City has determined that it is appropriate for the Gate-King Industrial Park Additional Analysis to rely on CLWA's SWP water supplies, including the 41,000 afy water transfer.

## 1. SWP OVERVIEW

As stated in the Gate-King Industrial Park Additional Analysis, from 1951 through 1959, the California Legislature authorized and funded construction of the SWP facilities, which are managed and operated by the California Department of Water Resources (DWR). SWP water supplies are used for both urban and agricultural uses throughout California.[1] The SWP facilities consist of a complex system of dams, reservoirs, power plants, pumping plants, canals, and aqueducts to deliver water throughout California.

At the inception of the SWP, DWR entered into individual water supply contracts with agricultural and urban water suppliers (SWP contractors). The contracts were the method used to fund construction and operation of the SWP facilities for the delivery of water to the SWP contractors. Each such contract sets forth the annual amount of water to which a SWP contractor is contractually entitled, which is stated in

1 Urban water uses also are referred to as "municipal and industrial," or "M&I," uses.

"Table A" to the contract (Table A Amount or allocation). However, the amount of SWP water actually available for delivery in any year may be an amount less than the contractor's maximum Table A amount due to hydrology, operational constraints, environmental constraints, and a number of other factors. The Table A Amount was previously referred to as "SWP entitlement."[2]

There are currently 29 SWP contractors that have entered into water supply contracts with DWR. A SWP contractor may annually request that DWR deliver water in the following year in any amount up to the SWP contractor's Table A Amount. The SWP contracts provide that in a year when DWR is unable to deliver the full amount of contractor requests, deliveries to contractors are reduced so that total deliveries equal total available supply for that year. CLWA's annual contractual Table A Amount is 95,200 afy. In the fall of each year, CLWA, along with all the other SWP contractors, submits a request to DWR for an allocation for the following year. DWR utilizes the factors noted above to "allocate" water among all contractors who have made requests, so that each contractor receives a percentage of its Table A Amount.

For example, if the SWP allocation is 40 percent of the Table A Amounts, each contractor receives 40 percent of its Table A Amount. If the allocation is 100 percent (as in 2006), each SWP contractor could receive the entire contractual Table A Amount. Therefore, CLWA's annual allocation is based on its total contractual Amount. **Table 1** indicates the actual Table A allocations made through the SWP since 1978.

The 41,000 afy water transfer amount is not kept "separate" as some have suggested. Since 2000, DWR has been including the 41,000 afy in the Table A Amount that is allocated in all allocations made to CLWA (based on its total annual allocation of 95,200 acre-feet). DWR has been *delivering* and the CLWA service area *receiving* water supply, including a percentage of the 41,000 afy, since calendar year 2000. While SWP contractors that receive water from the Delta currently hold Table A Amounts totaling approximately 4.13 million afy, the amount of Table A water actually delivered by the SWP may be less in some years due to hydrology, and operational and environmental constraints. Given existing SWP facilities, hydrology, operational and environmental conditions, and SWP contractor demands, the SWP is available to meet 100 percent of the SWP contractors' Table A requests this year (2006).[3] This 100

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2 As stated by the Court of Appeal in *Santa Clarita Organization for Planning the Environment v. County of Los Angeles* (2003) 106 Cal.App.4th 715, SWP Table A "entitlements" *are not equivalent to actual deliveries of water* because the amount of SWP water actually available for delivery in any given year may be an amount less than the Table A Amount. For example, the amount of SWP water actually available for delivery in any given year may be *reduced* due to several factors, including drought periods, increased SWP operational constraints, environmental water requirements/constraints (e.g., the listing of several fish species as endangered or threatened), water quality concerns, and other factors.

3 See, DWR *"News for Immediate Release,"* dated April 18, 2006, which is found in **Appendix J** of the Final Additional Analysis.

percent allocation of the Table A Amount to SWP contractors would add up to 4.13 million afy, distributed among the SWP contractors.[4]

**Table 1**
**Actual SWP Annual Allocations**

| Year | Percent Allocation | |
|---|---|---|
| | To Agricultural Contractors | To Urban (M&I) Contractors |
| 1978 to 1989 | 100 | 100 |
| 1990 | 50 | 100 |
| 1991 | 0 | 30 |
| 1992 | 45 | 45 |
| 1993 | 100 | 100 |
| 1994 | 50 | 50 |
| 1995 | 100 | 100 |
| 1996 | 100 | 100 |
| 1997 | 100 | 100 |
| 1998 | 100 | 100 |
| 1999 | 100 | 100 |
| 2000 | 90 | 90 |
| 2001 | 39 | 39 |
| 2002 | 70 | 70 |
| 2003 | 90 | 90 |
| 2004 | 65 | 65 |
| 2005 | 90 | 90 |
| 2006 | 100 | 100 |

*Source: California Department of Water Resources, State Water Project Analysis Office, 2006.*

This available supply varies from year to year. For example, in 2003, DWR approved deliveries of Table A Amount allocations, totaling 3.71 million acre-feet (or 90 percent of the 4.13 million acre-foot Table A Amount).[5] In 2002, DWR approved deliveries of Table A Amounts, totaling 2.89 million acre-feet (70 percent).[6] In 2001, DWR approved deliveries of Table A Amounts, totaling 1.61 million acre-feet (39 percent),[7] and in 2000, DWR approved deliveries of Table A Amounts, totaling 3.42 million acre-feet (90 percent).[8]

4 The original long-term water supply contracts between DWR and the SWP contractors assumed maximum annual Table A water deliveries of 4.23 million afy, assuming full development of the SWP. Currently, the maximum Table A Amounts for the SWP contractors that receive their supply from the Delta total approximately 4.13 million afy. (See, Final Additional Analysis, **Appendix AQ** [*SWP Delivery Reliability Report*, Public Review Draft, November 16, 2005, p. 7].)

5 See, DWR Bulletin 132-04, *Management of the California State Water Project*, September 2005, excerpts of which are provided in **Appendix O** of the Final Additional Analysis.

6 See, DWR Bulletin 132-03, December 2004 (**Appendix N** of the Final Additional Analysis).

7 See, DWR Bulletin 132-02, January 2004 (**Appendix M** of the Final Additional Analysis).

8 See, DWR Bulletin 132-01, December 2002 (**Appendix L** of the Final Additional Analysis).

The original plan for the SWP included constructing additional water storage and conveyance facilities as SWP contractor demands increased; however, very little new construction of SWP storage facilities has occurred since the SWP facilities were initially completed, and those facilities were never fully completed as contemplated in the 1950s. Although future construction or other actions could improve the quantity and reliability of SWP supplies, those actions would entail their own environmental reviews, potential litigation delays, and multi-year constructions periods.

## 2. CLWA'S 41,000 AFY WATER TRANSFER ACQUISITION

In 1999, CLWA purchased 41,000 afy of SWP Table A Amount from Kern County Water Agency (KCWA), acting on behalf of its member district, Wheeler Ridge-Maricopa Water Storage District. This purchase brought CLWA's total annual SWP Table A Amount to 95,200 afy; that purchase is generally referred to as the 41,000 afy water transfer.

The 41,000 afy water transfer was memorialized in a DWR/CLWA water supply contract amendment (Amendment No. 18), which reflects the *increase* in CLWA's annual allocation of SWP Table A Amounts from 54,200 afy to 95,200 afy. This increase reflects the permanent allocation of the 41,000 afy to CLWA (95,200 - 54,200 = 41,000).[9] As reported in the Gate-King Industrial Park Additional Analysis, the 41,000 afy water transfer has been completed, CLWA paid approximately $47 million for the additional Table A Amount, the monies have been delivered, the sales price has been financed through CLWA by tax-exempt bonds, and DWR increased CLWA's SWP Table A allocation, starting in calendar year 2000, because it was a permanent transfer/reallocation of SWP Table A water between SWP contractors.

Some comments have suggested that CLWA's 41,000 afy water transfer has not been approved by DWR. This is not correct. The 41,000 afy water transfer was approved by DWR on March 31, 1999, in the fully-executed amendment to CLWA's water supply contract (Amendment No. 18). Other comments have asserted that the 41,000 afy water transfer was not a "permanent" transfer of SWP Table A water. This also is incorrect. As stated by DWR in Bulletin 132-00, dated December 2001, at page 94, Amendment No. 18 "provided for the *permanent* transfer of 41,000 afy of SWP agricultural entitlement by CLWA from KCWA, . . . The transfer is consistent with implementation of the Monterey Amendment, which provides for the *permanent* transfer of up to 130,000 afy of agricultural entitlement to urban agencies." (Emphasis

9 A copy of "Amendment No. 18 to the Water Supply Contract between the State of California, Department of Water Resources and Castaic Lake Water Agency," dated March 31, 1999, is presented in **Appendix A** of the Final Additional Analysis.

added.) Importantly, since 2000, DWR has included the 41,000 afy in all allocations made to CLWA, based on CLWA's total annual Table A allocation of 95,200 acre-feet.[10]

To further support the fact that CLWA's 41,000 afy water transfer was a "permanent" transfer/ reallocation of SWP Table A Amount from one SWP contractor to another, in Bulletin 132-04 (September 2005), at page 120, DWR identified all eight Table A transfers, including the 41,000 afy water transfer, as "permanent" transfers under the Monterey Amendments. Furthermore, DWR has confirmed that the parties to the Monterey Settlement Agreement "recognize that the Kern-Castaic Lake Water Agency 41,000 afy Table A transfer is subject to pending litigation and agree that jurisdiction with respect to that litigation remain[s] in the Los Angeles County Superior Court and that nothing in the [Monterey Settlement Agreement] is intended to predispose the remedies or other actions that may occur in the pending litigation." In that same Bulletin, at page 120, DWR has also pointed out that the potential environmental effects of all eight "permanent Table A transfers" under the Monterey Amendments, including the 41,000 afy water transfer, will be analyzed in DWR's new Monterey EIR.[11] (The Monterey Amendments and related Monterey Settlement Agreement are discussed in further detail below). Thus, there is no basis to distinguish the 41,000 afy transfer and the other permanent Table A transfer, except for the California Environmental Quality Act (CEQA) litigation discussed in **Section 6**.

## 3. MONTEREY AMENDMENTS

In 1994, disputes arose between DWR and many agricultural and urban SWP contractors regarding the availability and distribution of water through SWP facilities. To avoid potential litigation, those parties met in Monterey, California, to attempt to resolve their ongoing disputes and, after negotiations, they agreed to a statement of principles, which became known as the "Monterey Agreement." The Monterey Agreement, signed by DWR and many of the agricultural and urban SWP contractors, established principles to be incorporated into contract amendments (the "Monterey Amendments"), which were primarily intended to increase the reliability of all SWP water supplies, stabilize SWP's rate structure, and increase water management flexibility for all SWP contractors. To date, all but two SWP contractors have accepted the Monterey Amendments. The Monterey Amendments included, among other benefits, water transfers among SWP contractors. Specifically, under the Monterey Amendments, SWP contractors may transfer unneeded Table A water to other contractors on a permanent basis, which provides financial relief from SWP charges for the seller and additional water supplies for the buyer. The Monterey

10 Please see **Appendix R** through **X** of the Final Additional Analysis for DWR's "Notices to State Water Project Contractors," informing them of increases or decreases in approved Table A Amounts from 2000 to 2006. In the 2006 Notice, CLWA's Table A allocation is shown as 95,200 afy, and in all of the prior Notices, CLWA's Table A allocation is shown in two places, once under the "San Joaquin Valley" heading, which shows the allocation at 12,700 afy, and again under the "Southern California" heading, which shows the allocation at 82,500 afy, totaling 95,200 afy.

11 See, DWR Bulletin 132-04 (September 2005), p. 120 (**Appendix O** of the Final Additional Analysis).

Amendments have facilitated the transfer of 130,000 afy of SWP Table A Amounts from agricultural to urban SWP contractors.[12] Many such transfers were implemented soon after the Monterey Amendments became effective. CLWA's 41,000 afy water transfer was one of the water transfers effected by the Monterey Amendments.

## 4. ENVIRONMENTAL REVIEW OF MONTEREY AMENDMENTS AND SUBSEQUENT LITIGATION

A Program EIR was prepared and certified to analyze the environmental effects of implementing the Monterey Agreement/Monterey Amendments. The adequacy of the Program EIR was challenged in litigation filed in 1995 in the Sacramento County Superior Court, and the Superior Court upheld the adequacy of the Program EIR. Before and after the Sacramento County trial court's decision, DWR and the agricultural and urban SWP contractors who had executed the Monterey Agreement began implementing various amendment provisions, including the completion of permanent transfers of Table A Amounts among agricultural and urban SWP contractors. Again, CLWA's 41,000 afy water transfer was one of eight water transfers effectuated by the Monterey Amendments. The trial court's decision was subsequently appealed. On appeal, the petitioners sought an injunction to prevent further implementation of the Monterey Agreement during the appeal. However, the appellate court denied the requested injunction.

The appellate court ultimately reversed the trial court's decision. The appellate court held that the Program EIR was improperly prepared by the Central Coast Water Agency, as "Lead Agency" under CEQA, rather than by DWR, which should have been the "Lead Agency." The appellate court also found that the EIR did not sufficiently discuss implementation of a "no project" alternative, and concluded that a new EIR must be prepared and certified.

The appellate court then remanded the case to the Sacramento County trial court and directed that the trial court issue a writ of mandate vacating certification of the EIR and retaining jurisdiction until DWR, as lead agency, prepared and certified an EIR in accordance with CEQA. The appellate court further directed that the trial court consider whether the Monterey Amendments may continue to be

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12 Neither the Monterey Agreement nor the Monterey Amendments created a new right to carry out permanent transfers of SWP Table A Amounts. That right had existed since the early 1960s through Article 41 of the SWP contracts. The Monterey Amendments simply provided a vehicle through which the SWP agricultural contractors promised that they would support such Article 41 transfers up to 130,000 acre feet. The Monterey Amendments also did not limit the SWP contractors' rights to implement permanent transfers under existing law other than those described in the Monterey Amendments. (See, e.g., Water Code §§382, 383.)

implemented while the new EIR is being prepared. (*Planning & Conservation League v. Department of Water Resources* (2000) 83 Cal.App.4th 892.)[13]

The appellate court decision invalidated certification of the Program EIR, but did not set aside, invalidate or otherwise vacate the Monterey Amendments or enjoin the water transfers effected thereunder. Instead, the appellate court directed the trial court to consider under CEQA whether the Monterey Amendments should remain in place pending DWR's preparation of a new EIR, and to retain jurisdiction pending certification of that EIR. In addition, no court orders have ever been issued to "stay" further implementation of the Monterey Amendments.

## 5. THE MONTEREY SETTLEMENT AGREEMENT

In March 2001, before the Sacramento County trial court had acted on remand, the parties to the *PCL* litigation entered into settlement negotiations. In May 2003, DWR, Central Coast Water Authority, Planning and Conservation League, certain SWP contractors (including CLWA) and other entities entered into a final settlement of the *PCL* litigation (the "Monterey Settlement Agreement").[14] Under the Monterey Settlement Agreement, the parties expressly agreed that the SWP would continue to be administered and operated in accordance with both the Monterey Amendments and terms of the Monterey Settlement Agreement:

> *"Pending the Superior Court's issuance of an order discharging the writ of mandate in the underlying litigation, the Parties will jointly request that the Superior Court enter an order approving this Settlement Agreement, and an order, pursuant to California Public Resources Code Section 21168.9, authorizing on an interim basis the administration and operation of the SWP . . . in accordance with the Monterey Amendments, [and] the terms of this Settlement Agreement. ..." (Final Additional Analysis,* ***Appendix AF*** *[Monterey Settlement Agreement, p. 9].)*

The Monterey Settlement Agreement did not set aside, invalidate, or otherwise vacate the Monterey Amendments, or any of the water transfers effectuated under the Monterey Amendments. On June 6, 2003, the Sacramento County Superior Court issued the requested order, pursuant to CEQA (Pub.Res.Code Section 21168.9), approving both the Monterey Settlement Agreement and the administration and operation of the SWP pursuant to the Monterey Amendments and the terms of the approved agreement.[15]

Section III(C)(4) of the Monterey Settlement Agreement required DWR to carry-out an "[a]nalysis of the potential environmental effects relating to" eight water transfers under the Monterey Amendments,

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13 The decision, *Planning and Conservation League v. Department of Water Resources* (2000) 83 Cal.App.4th 892, hereafter referred to as "*PCL*," is presented in **Appendix AI** of the Final Additional Analysis.

14 The Monterey Settlement Agreement is presented in **Appendix AF** of the Final Additional Analysis.

15 The Sacramento County trial court's Order is presented in **Appendix AR** of the Final Additional Analysis.

seven so-called "Attachment E Transfers" and the 41,000 afy water transfer, also referred to in the agreement as the "Kern-Castaic Transfer." Further, the Monterey Settlement Agreement obligated DWR to evaluate all eight of the water transfers in the same manner, even though seven of them, defined in the agreement as the "Attachment E Transfers," were no longer subject to legal challenge. (See, Final Additional Analysis, **Appendix AF** [Monterey Settlement Agreement, Sections III(C)(4), III(D), III(E), pp. 11-12].) The point of the DWR review of the eight transfers was not to determine whether to continue the transfers, because seven of them beyond CEQA challenge, and the eighth, the 41,000 afy transfer, was also a permanent transfer, but it was still subject to litigation. Rather, the point of the DWR review of all eight transfers was to examine the environmental effects of such transfers in light of the Monterey Agreement as a whole.

In fact, Section III(D) of the Monterey Settlement Agreement affirmed that none of the parties could challenge the effectiveness or validity of the Attachment E Transfers, which had been litigated in other forums or had become final without challenge by the expiration of applicable statutes of limitations. According to CLWA and other signatories to the Agreement, this is why Section III(D) referred to the Attachment E Transfers as "final." (See, Final Additional Analysis, **Appendix AF** [Monterey Settlement Agreement, Section III(D), p. 12].) The 41,000 afy water transfer was not included among the Attachment E transfers, only because the 41,000 afy water transfer was then under the jurisdiction of the Los Angeles County Superior Court and that litigation was ongoing.[16]

Section III(E) protects the jurisdiction of the Los Angeles County Superior Court in connection with the then-pending CEQA litigation challenging the validity of CLWA's EIR on the 41,000 afy water transfer. Section III(E) states, in part: "nothing in this Settlement Agreement is intended to predispose the remedies or other actions that may occur in that pending litigation." As set forth below, Section III(E) provides:

> *"Acknowledgement and Agreement Regarding Kern-Castaic Transfer [the 41,000 afy water transfer]. With respect to Section III(C)(4)(b) regarding the Kern-Castaic Transfer, the Parties* recognize that such water transfer is subject to pending litigation in the Los Angeles County Superior Court *following remand from the Second District Court of Appeal. (See* Friends of the Santa Clara River v. Castaic Lake Water Agency, *95 Cal.App.4th 1373, 116 Cal.Rptr.2d 54 (2002);* review denied *April 17, 2002.) The Parties agree that* jurisdiction *with respect to that litigation should* remain *in that court and that* nothing in this Settlement Agreement is intended to predispose the remedies or other actions that may occur in that pending litigation." (Emphasis added.) *(Final Additional Analysis,* ***Appendix AF*** *[Monterey Settlement Agreement, Section III(E), p. 12].)*

16 In Section VII(I), the parties further agreed that, should the certification of DWR's new EIR be challenged, the challenging parties must stipulate to the continued administration and operation of the SWP during the pendency of that challenge, and, should that challenge be successful, during any future challenges to future DWR EIR's. In turn, Section VII(I), subdivision (1), limits the grounds on which DWR's return to the writ of mandate can be legally challenged, and Section VII(J) prohibits any future litigation challenging the validity of any Monterey Amendments (or any portions thereof). Finally, Sections VII(L) and IX provide that all disputes regarding the Monterey Settlement Agreement must be mediated.

The Monterey Settlement Agreement does not preclude CLWA, a signatory to that agreement, from using the 41,000 afy water transfer as part of its overall SWP Table A supplies for planning purposes. First, the language of the Monterey Settlement Agreement, quoted above, does not state that CLWA may not rely on the 41,000 afy water transfer (also referred to as the Kern-Castaic transfer). Second, nothing in the Monterey Settlement Agreement precludes a project EIR from referencing and using all of CLWA's SWP Table A supplies in analyzing available water supplies for the Santa Clarita Valley. Given that the 41,000 afy water transfer was specifically covered by the Monterey Settlement Agreement, if the parties to that agreement had intended to preclude reliance on the 41,000 afy water transfer, they surely could and would have spelled out that prohibition. Rather than prohibiting CLWA or others from relying on the 41,000 afy water transfer, the Monterey Settlement Agreement simply clarified that the transfer was (and remains today) under the jurisdiction of the Los Angeles County Superior Court.

In addition, the Monterey Settlement Agreement allows implementation of the Monterey Amendments and validates the water transfers that already had taken place by the time that agreement took effect. The only reason the 41,000 afy water transfer was not included on the list of "final" transfers in Attachment E for purpose of that agreement was that it was the subject of ongoing litigation. The 41,000 afy water transfer was both a permanent and final reallocation of SWP Table A Amounts from one SWP contractor to another (CLWA), just as were the other seven transfers; the pending 41,000 afy water transfer litigation did not convert that transfer from permanent to temporary.

Importantly, DWR, itself, includes the 41,000 afy to CLWA in its published "Notices to State Water Project Contractors." For example, on April 18, 2006, DWR sent its notice to SWP contractors stating that DWR was increasing its allocation of 2006 SWP water to its contractors. The table attached to that Notice listed all such contractors' Table A Amounts, and their approved allocations. CLWA's Table A Amount is listed under the Southern California heading in the amount of 95,200 afy, which includes CLWA's 41,000 afy. If DWR, the agency that administers the SWP, did not consider CLWA's 41,000 afy water transfer to be both a permanent and final reallocation of SWP Table A Amounts, it would not publish CLWA's total Table A allocation at 95,200 afy.[17]

Contrary to comments received from C-WIN and Friends, which attempt to place a cloud over CLWA's reliance upon the 41,000 afy water transfer, the terms of the Monterey Settlement Agreement make clear that the agreement was intended to protect the Los Angeles County Superior Court's jurisdiction in the pending 41,000 afy water transfer litigation. Nothing in that agreement characterized the 41,000 afy water transfer as not final. And, nothing in that agreement prohibited any party, agency, or other entity from relying on the 41,000 afy water transfer for planning purposes.

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17 DWR's April 18, 2006, "Notice to State Water Project Contractors" is presented in **Appendix S** of the Final Additional Analysis.

## 6. CLWA ENVIRONMENTAL REVIEW OF 41,000 AFY WATER TRANSFER AND LITIGATION

Prior to completion of the 41,000 afy water transfer, the proposed transfer was the subject of environmental review by CLWA and KCWA and its member district. The agencies selling the 41,000 afy of SWP Table A Amount to CLWA assessed the environmental consequences of the proposed transfer within their service area in a Final EIR, dated June 1998. That EIR was certified in 1998 and was not challenged in court. As a result, that EIR is conclusively presumed to be valid (Pub. Res. Code §21167.2).

CLWA also prepared a supplemental Final EIR, which assessed the environmental effects of CLWA's acquisition of the 41,000 afy within its service area. The Board of Directors of CLWA certified the Supplemental Final EIR in March 1999. Thereafter, in April 1999, a lawsuit was brought in the Los Angeles County Superior Court challenging the adequacy of the EIR under CEQA (*Friends of the Santa Clara River, et al. v. Castaic Lake Water Agency, et al.*, Case No. BS 056954, also referred to as "*Friends*"). The Los Angeles County trial court in the *Friends* litigation ruled in favor of CLWA and upheld the adequacy of the EIR under CEQA.

In October 2000, the *Friends* petitioners filed an appeal. During the pendency of the *Friends* appeal, the Third District Court of Appeal issued the *PCL* decision, which found the Monterey EIR inadequate and ordered it decertified.[18] On appeal in *Friends*, the Second District Court of Appeal considered the *Friends* petitioners' multiple arguments, and concluded that CLWA's EIR on the 41,000 afy water transfer must be decertified, not because the EIR was substantially inadequate or failed to support the analysis of the transfer's approval, but only because it had been "tiered" from the Monterey EIR, recently found to be inadequate:

> "*We have examined all of appellant's other contentions and find them to be* without merit. *If the* PCL/*tiering problem had not arisen,* we would have affirmed the judgment."[19] (Emphasis added.)

Nonetheless, like the Third District Court of Appeal in the *PCL* decision, the Second District Court of Appeal in *Friends* refused to issue any ruling affecting CLWA's ability to continue to rely on the 41,000

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18 Please refer to **Appendix AI** of the Final Additional Analysis for the *PCL* decision.

19 The January 2002 *Friends* decision entitled, *Friends of the Santa Clara River v. Castaic Lake Water Agency* (2002) 95 Cal.App.4th 1373, is found in **Appendix AA** of the Final Additional Analysis. The *Friends* decision provides useful factual background information concerning the Monterey Amendments, the Monterey Amendments EIR, water transfers authorized by the Monterey Amendments, the local agency environmental review of the 41,000 afy water transfer, CLWA's acquisition of the 41,000 afy, and the relationship between the *PCL* decision and the *Friends* decision. See, Final Additional Analysis, **Appendix AA** [*Friends* decision, pp. 1376-1384].

afy water transfer, leaving it to the trial court's discretion whether or not to enjoin CLWA's use of the water pending its completion of a new EIR.[20]

In December 2002, on remand to the Los Angeles County Superior Court, the *Friends* petitioners sought to enjoin CLWA's use of, and reliance upon, the 41,000 afy water transfer under CEQA, but the trial court rejected that request. Specifically, the trial court maintained its jurisdiction over the matter and authorized CLWA to utilize any of the 41,000 afy subject to the following order:

> *"Respondent [CLWA] will not be prohibited from using the water to which it is entitled, but Petitioner may renew its application for such prohibition based upon evidence of the actual use of such additional water for purposes it considers improper."*[21]

The *Friends* petitioners never pursued the trial court's suggestion for them to "renew" their request to prohibit the use of the 41,000 afy water transfer "based upon evidence of the actual use of such additional water for purposes it considers improper." Instead, the *Friends* petitioners appealed the trial court's judgment and, again, requested that the use of the 41,000 afy water transfer be prohibited.

However, on December 1, 2003, in an unpublished decision, the Second District Court of Appeal affirmed the trial court's ruling allowing CLWA to utilize and rely on the 41,000 afy water transfer pending completion of its new EIR.[22] Significantly, petitioners and others in the *Friends II* decision argued that the trial court's determination of whether to enjoin CLWA's use of the 41,000 afy water transfer should be based on the status of the *PCL* litigation and DWR's new EIR for the Monterey Amendments the same argument they advance here. In making that argument, they relied on language in the original *Friends* decision in which the Court of Appeal suggested that *as one option* CLWA "may be able to cure the *PCL* problem by awaiting action by the DWR complying with the *PCL* decision, then issuing a subsequent EIR, supplement to EIR, or addendum to EIR . . . tiering upon a newly certified Monterey Agreement EIR."[23] The Court of Appeal in *Friends II*, however, rejected this argument, explaining:

> *"Amici misapprehend our directions to the trial court. As explained above, those directions are found in the dispositional language of our opinion. That language directed the trial court,* inter alia, *to "consider such orders it deems appropriate under [Pub.Res.Code] section 21168.9." [Citation.] That section grants the trial court broad powers to fashion equitable relief. [Note.]* Amici's argument that the exercise of said discretion was to be based upon the status of either the PCL litigation or the new EIR for the Monterey Agreement is at odds with the clear dispositional language we employed. *The two paragraphs in our opinion upon which* amici *rely were merely suggestions as to how respondent could proceed and a statement that, in exercising its discretion whether to grant equitable relief pending completion of a new EIR for this project, the trial court could ascertain, and if it so chose, rely upon the status of the PCL litigation*

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20 See, Final Additional Analysis, **Appendix AA** [*Friends* decision, p. 1388].

21 For the trial court's decision, please refer to **Appendix AA**, p. 2 ¶6, of the Final Additional Analysis.

22 For the Court of Appeal's unpublished opinion, please refer to **Appendix Y** of the Final Additional Analysis [*Friends of the Santa Clara River v. Castaic Lake Water Agency*, 2003 WL 22839353 (*Friends II*)].

23 Please see **Appendix Y** of the Final Additional Analysis (*Friends II*, p. 16).

> *and new Monterey Agreement EIR."* (Emphasis added; *Final Additional Analysis, **Appendix Y** [*Friends II, *p. 17].)*

The Court of Appeal not only refused to enjoin the 41,000 afy water transfer, but also made it clear that CLWA's use of that water is not legally bound to either the *PCL* litigation or to DWR's new EIR for the Monterey Amendments.

Accordingly, neither the *PCL* litigation, the Monterey Settlement Agreement, nor the *Friends* or *Friends II* litigation has changed the status of the 41,000 afy water transfer from a permanent, final allocation of SWP Table A water to a "temporary or non-final" water transfer. To the contrary, the Monterey Settlement Agreement specifically provides that the SWP will continue to be administered and operated in accordance with both the Monterey Amendments and the terms of the Settlement Agreement, and the *Friends* trial court issued its Judgment permitting CLWA to continue to use the 41,000 afy, a decision that the Second District Court of Appeal affirmed. Thus, the two courts charged with responsibility over the 41,000 afy water transfer have determined that CLWA may continue to use the water to which it is entitled pending preparation of CLWA's new EIR.

Furthermore, CLWA completed and, on December 22, 2004, certified its new EIR on the 41,000 afy water transfer.[24] The CLWA 2004 EIR fully analyzed the environmental implications of the 41,000 afy water transfer without tiering from the Monterey EIR.[25] On December 30, 2004, CLWA lodged the certified Final EIR with the Los Angeles County Superior Court, as part of its "return" to the trial court's writ of mandate issued by the trial court as directed in the *Friends I* decision. There was no opposition filed to CLWA's return, which challenged the adequacy of CLWA's 1999 EIR on the 41,000 afy water transfer. On February 1, 2005, petitioner, Friends of the Santa Clara River, filed a request for entry of a dismissal with prejudice of the *Friends I* action, which was subsequently entered by the Los Angeles County Superior Court, terminating the *Friends I* action.

CLWA's 2004 EIR is currently the subject of two other legal challenges brought by C-WIN and Planning and Conservation League in January 2005. Despite the pending litigation, however, an EIR is presumed adequate under CEQA, and the plaintiff in a CEQA action has the burden of proving otherwise.[26] Because the CLWA 2004 EIR was overturned solely because it tiered from a later-decertified Monterey EIR and would otherwise have been affirmed, and because CLWA has now completed and certified the 2004 EIR approving the 41,000 afy water transfer without tiering from a Monterey EIR, the City has

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24 For a copy of CLWA Resolution No. 2354 certifying the Final EIR on the 41,000 afy transfer, and approving that project, please refer to **Appendix I** of the Final Additional Analysis.

25 CLWA's Draft and Final EIR (SCH No. 1998041127) for the 41,000 afy water transfer are incorporated by reference and available for public review and inspection at the City of Santa Clarita, 23920 Valencia Boulevard, Santa Clarita, California, Contact: Mr. Jason Mikaelian, AICP, (661) 255-4330.

26 See, e.g., Pub.Res.Code §21167.3(b), CEQA Guidelines §15231; *Barthelemy v. Chino Basin Water Dist.* (1995) 38 Cal.App.4th 1609, 1617.

determined, based on substantial evidence in the record as a whole, that it remains appropriate for the Gate-King Industrial Park Additional Analysis to include those water supplies in its water supply and demand analysis, while acknowledging and disclosing the potential uncertainty created by the pending litigation.

On a related matter, the City has noted that DWR submitted a comment letter on CLWA's 2004 EIR for the 41,000 afy water transfer project. In that letter, DWR stated that CLWA's 2004 EIR "adequately and thoroughly discusses the proposed project and its impacts."[27] DWR's letter specifically addressed DWR's new Monterey EIR and the relationship between that EIR and the CLWA 2004 EIR, stating:

> *"The DEIR provides a good discussion of the relationship between the 41,000 acre-feet Table A transfer and the current Monterey Plus [the new Monterey EIR] process. DWR will analyze the effects of all Table A transfers that were part of the Monterey Amendment to the SWP contracts [e.g., both the 41,000 afy and the Attachment E transfers] in the Monterey Plus EIR."* Id.

DWR's comment letter contains no statement or suggestion that the 41,000 afy water transfer is contingent on DWR's approval, or on DWR's new Monterey EIR, or is in any other way not permanent.

## 7. UNCERTAINTIES CONCERNING CLWA'S 41,000 AFY WATER TRANSFER

The comment letters argue that the pending litigation challenges to CLWA's 2004 EIR for the 41,000 afy transfer, and DWR's preparation of a new Monterey Agreement EIR, introduce an element of potential uncertainty regarding the 41,000 afy water transfer. The City has acknowledged and considered these potential uncertainties, and concluded that, based on a review of all the surrounding circumstances, these events do not significantly affect the reliability of the transfer amount. Therefore, the City has concluded that it is still appropriate to rely on the transfer amount as part of CLWA's 95,200 afy Table A Amount, for the reasons discussed below.

- First, the 41,000 afy water transfer was memorialized in 1999 in a DWR/CLWA water supply contract amendment, and DWR has allocated and annually delivered the water in accordance with the completed transfer since 2000. At the same time, DWR and KCWA executed Amendment No. 28 to the water supply contract between these parties, which also provided for the permanent transfer of the 41,000 afy by KCWA, acting on behalf of its member district, to CLWA, which DWR also stated was consistent with the implementation of the Monterey Amendments. Neither of these contract amendments was ever legally challenged, and both are considered permanent and in full force and effect. In connection with that transfer, CLWA paid approximately $47 million for the additional 41,000 afy Table A supply, the monies have been delivered, the sale price has been financed through the sale of CLWA tax-exempt bonds, and DWR has approved and amended CLWA's long-term water supply contract to reflect the increase in CLWA's SWP Table A Amount, and the permanent transfer and reallocation of SWP Table A supply between SWP contractors.

- Second, DWR has from its inception treated the 41,000 afy water transfer as a "permanent" Table A transfer from one SWP contractor to another, and has stated that the transfer is consistent with

27 For a copy of the DWR letter, dated July 30, 2004, commenting on CLWA's EIR for the 41,000 afy water transfer, please refer to **Appendix P** of the Final Additional Analysis.

implementation of the Monterey Amendments, which provide for the "permanent" transfer of up to 130,000 afy of agricultural Table A Amounts to urban SWP contractors.

- Third, the Court of Appeal held that the only defect in the 1999 CLWA EIR was that it tiered from the Monterey EIR, which was later decertified. This defect has now been remedied by CLWA's preparation in 2004 of a new EIR that did not tier from the Monterey EIR. CLWA's 2004 EIR is presumed adequate pending resolution of the latest legal challenges to that EIR.

- Fourth, the Monterey Settlement Agreement expressly authorized the operation of the SWP in accordance with the Monterey Amendments and the terms of the settlement agreement. The Monterey Amendments, which are still in effect, authorized SWP contractors to transfer unneeded SWP supply amounts to other contractors on a permanent basis. Specifically, the Monterey Agreement provisions authorized 130,000 afy of agricultural SWP contractors' entitlements to be available for sale to urban SWP contractors. CLWA's 41,000 afy acquisition was a part of the 130,000 afy of SWP Table A supply that was transferred, consistent with the Monterey Amendments. The 41,000 afy transfer was not listed on Attachment E to the Monterey Settlement Agreement with the other permanent transfers because it was the only permanent transfer that was subject to then pending litigation (i.e., the *Friends I* litigation). The Monterey Settlement Agreement otherwise treated all eight of the permanent transfers the same, and provided that DWR's new EIR would do so, as well, as DWR has affirmed in a letter commenting on the CLWA 2004 EIR for the 41,000 afy water transfer. No other transfers that were part of the 130,000 afy were the subject of litigation.

- Fifth, as to the new Monterey EIR, the Court of Appeal in the 41,000 afy litigation has stated that CLWA's use of the 41,000 afy is not legally bound to the *PCL* litigation, or to DWR's new Monterey EIR. In addition, DWR did not oppose CLWA's completion and certification of the EIR for the 41,000 afy water transfer, independent of DWR's new Monterey EIR. Thus, the pending legal challenges to the CLWA EIR, and DWR's preparation of a new Monterey EIR, should have no impact on the amount of SWP water available to CLWA as a result of the completed 41,000 afy water transfer.

- Sixth, two courts have refused to enjoin the 41,000 afy water transfer, pending CLWA's preparation of a new EIR, and this EIR is now completed and certified by CLWA as adequate and complete under CEQA. CLWA also filed the 2004 EIR on the 41,000 afy transfer with the Los Angeles County Superior Court as part of its "return" to the trial court's writ of mandate as directed in the *Friends I* decision. Thereafter, the petitioner voluntarily dismissed that action, resulting in its termination. As a result, both the CLWA 2004 EIR and the 41,000 afy water transfer are no longer subject to challenge in the *Friends I* action. This litigation finality brings further certainty to the permanent 41,000 afy water transfer.

- Seventh, as stated above, CLWA's amended water supply contract documenting the 41,000 afy water transfer remains in full force and effect, and no court has ever questioned the validity of the contract or enjoined the use of this portion of CLWA's SWP Table A Amount.

Other comments have stated that the Monterey Settlement Agreement requires that DWR's new Monterey EIR analyze, among others, the 41,000 afy water transfer; and, therefore, water from that transfer should not be relied upon until DWR completes its new EIR. The City does not concur with these comments.

First, nothing in either the Monterey Settlement Agreement or the related court orders preclude CLWA from using or relying upon the 41,000 afy water transfer, which remains intact pending completion of the DWR EIR. Second, nothing in the terms of the Monterey Settlement Agreement precludes CLWA from proceeding with its 2004 EIR to address the environmental implications of the 41,000 afy water transfer.

Again, if the Monterey Settlement Agreement had intended such a result, then it is reasonable to assume that provisions would have been included in that agreement making it clear that CLWA could not proceed with its own EIR on the 41,000 afy water transfer. In fact, no such provisions were included in the Monterey Settlement Agreement, because such provisions would have interfered with the jurisdiction of another court in the separately pending 41,000 afy water transfer litigation. Finally, although the Monterey Settlement Agreement requires the new Monterey EIR to analyze the potential environmental effects relating to CLWA's 41,000 afy water transfer as well as the other permanent transfers, it does not, and cannot, preclude CLWA from conducting its own environmental review of that transfer. Indeed, CLWA *was required* by court order to prepare a new EIR to address the environmental implications of the 41,000 afy water transfer.[28] In the meantime, however, there are no court orders precluding CLWA from using or relying on that water supply. And, as discussed below, CLWA already has completed and certified the 2004 EIR, which has addressed the environmental impacts of the 41,000 afy water transfer, without tiering or relying on the decertified 1995 Monterey EIR.

In short, CLWA's 2004 EIR provides the environmental analysis for the 41,000 afy water transfer, which is required by CEQA and the orders and opinions issued in the 41,000 afy water transfer litigation. Nothing in CEQA or any law, regulation, or agreement constrains or limits CLWA's discretion to proceed with its own EIR on the 41,000 afy water transfer.

For all these reasons, The City of Santa Clarita has determined that it remains appropriate to rely on the 41,000 afy water transfer as part of CLWA's SWP Table A water supplies. Furthermore, based on the above, the City has determined that it is reasonable to conclude that even if a court finds the CLWA 2004 EIR legally deficient, that court, like all others before it, will again refuse to enjoin the permanent 41,000 afy water transfer, and instead require further revisions to that EIR. Therefore, the pending legal challenges to the 41,000 afy water transfer should have no impact on the amount of SWP water available to CLWA as a result of the completed 41,000 afy water transfer.

## 8. OTHER LITIGATION CONCERNING THE 41,000 AFY TRANSFER

The CLWA 41,000 afy water transfer also has been the subject of two recent court decisions. The first court case involved a published appellate court decision in *California Oak Foundation v. City of Santa Clarita* (2005) 133 Cal.App.4th 1219. In the *California Oak Foundation* decision (the decision setting aside the first EIR for this project), the Court of Appeal invalidated an EIR under CEQA for the Gate-King project

28 In the Judgment granting the writ of mandate setting aside CLWA's certification of the 41,000 afy EIR, the trial court specifically retained "jurisdiction until respondent Castaic Lake Water Agency certifies an Environmental Impact Report that complies with the California Environmental Quality Act and is consistent with the views expressed by the Court of Appeal Opinion, filed January 10, 2002, Case No. B145283." (Final Additional Analysis, **Appendix AC** [Judgment Granting Peremptory Writ of Mandate, dated October 25, 2002, p. 2, ¶3].)

located in the City of Santa Clarita, because the EIR did not explain how demand for water would be met if the 41,000 afy water transfer were set aside, or, alternatively, why it is appropriate to rely on the 41,000 afy transfer in any event. The above analysis explains in detail why it is appropriate to rely on the 41,000 afy water transfer as part of CLWA's SWP water supplies. None of this information or analysis was contained in the Gate-King EIR. In short, the Gate-King Industrial Park Additional Analysis supplies the information supporting the decision to rely on the 41,000 afy transfer, which the *California Oaks* court indicated was needed. A copy of the *California Oak Foundation* decision is provided in Appendix 3.0-21 of the Draft Additional Analysis.

The second court case involved a separate legal challenge under CEQA to an EIR for the West Creek project, located in Los Angeles County. This separate legal challenge was brought in Santa Barbara County Superior Court in *Santa Clarita Organization for Planning the Environment v. County of Los Angeles,* Case No. 1043805 (*West Creek* litigation). After a hearing, the Santa Barbara County Superior Court issued an Order determining that the EIR prepared for the West Creek project contained substantial evidence in the record to support Los Angeles County's decision to rely on the 41,000 afy water transfer for planning purposes. The Order noted that substantial evidence appeared in the record to support the County's decision to rely on the 41,000 afy water transfer, while acknowledging and disclosing the potential uncertainties involving the 41,000 afy water transfer created by pending litigation. The Order summarized the evidence, including the fact that: (a) DWR continues to allocate and deliver the water in accordance with the amended water supply contract authorizing the 41,000 afy transfer; (b) neither the *PCL* litigation, nor the Monterey Settlement Agreement set aside any of the water transfers made under the Monterey Amendments, including the 41,000 afy water transfer; (c) the courts have not enjoined CLWA's use of the 41,000 afy water transfer; and (d) CLWA has prepared and certified a new EIR on the 41,000 afy water transfer and that EIR is presumed adequate despite pending legal challenges. A copy of the trial court Order in the *West Creek* litigation is provided in **Appendix AU** of this Additional Analysis. The *West Creek* decision is currently on appeal.

In conclusion, one of the primary purposes of this Additional Analysis topical response is to respond to public comments and to inform decision makers and the public of pending and related litigation concerning CLWA's 41,000 afy water transfer, so that the information can be taken into account in determining whether there is adequate water supply for the Gate-King Industrial Park project, in addition to existing and planned future uses in the Santa Clarita Valley. In making that informed decision, the law does not require a showing of freedom from all legal challenges for a source of water to be included in overall SWP water supplies. Based on the above information, the City has determined that CLWA's 41,000 afy water transfer is sufficiently certain, so that it is not only permissible, but also reasonable, to include the 41,000 afy in CLWA's water supply sources for the Santa Clarita Valley.

# Attachment 23-E

*DRAFT ENVIRONMENTAL IMPACT REPORT*

# *The Keystone Project*

THE KEYSTONE

*Prepared for:*
City of Santa Clarita

*Prepared By:*
CHRISTOPHER A. JOSEPH & ASSOCIATES
Environmental Planning and Research

July 2005

Pages omitted.

Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

**Table II.1**
**Summary of Significant Environmental Impacts and Mitigation Measures**

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| **AESTHETICS** | | |
| ***Scenic Vistas***<br>The Proposed Project would introduce a residential development project with a junior high school site and YMCA site into the scenic vistas of the Santa Clarita Valley. The Proposed Project would provide an innovative and effective strategy for reducing the visual effects of the development. The strategy includes re-created ridgelines include manufactured berms that have the appearance of natural ridgelines with elevation peaks higher than the development pad areas. Manufactured (or super) slopes would be provided on the project site as previously described. These slopes create the sides to the development pads that include various gradients and curvature, emulating the existing topography. These slopes include peak elevations similar in height to the existing ridgelines, provide the base or side to the development pads, and include berms to camouflage portions of the development. As discussed above, the project site is not visible from the north or west and, therefore, would have no visual impact with respect to land uses in those directions. As shown in the view simulations, the site design and grading techniques would be effective in reducing the project's visual impact as seen from locations south of the project site and would minimize the effects of grading to insure that the natural character of ridgelines are preserved. | None required. | Less Than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| In balance, given the effectiveness with which the project minimizes its visual impacts to the larger community of the Santa Clarita Valley, it is concluded the project would not have a substantial adverse effect on a scenic vista. Therefore, the Proposed Project's impacts on scenic vistas would be less than significant. | | |
| ***Scenic Resources***<br>The major scenic resources on the project site are the Primary and two Secondary Ridgelines and the open space. There are no outstanding scenic trees, rock outcroppings or historic building on the project site. The project would not affect the Primary Ridgeline and although portions of the secondary ridgelines would be altered, they would be recreated in essentially the same locations, would retain their basic forms and elevations, and would be contour graded to blend back into the natural adjoining hillsides. Large areas of open space would be retained by the Proposed Project, natural areas would be incorporated into the development areas, and much of the proposed development areas would be screened from view by constructed perimeter ridgelines. Project impacts with respect to scenic resources would be less than significant. | None required. | Less Than Significant |
| ***Visual Character***<br>The project site is not visible from Bouquet and Plum Canyons and, therefore, would have no visual impact to those areas. The Proposed Project would be visible from adjacent residential development to the east and the west, as well as from the existing development located south of the Santa Clara River. From these | None feasible. | Significant and Unavoidable |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| areas, the project would be sent to convert undeveloped hillsides into a developed environment of housing, landscaping and institutional uses. Views of existing topography and native vegetation would be reduced or eliminated.<br><br>For the Alta Knoll Drive community located to the northwest, the most visually prominent change would be the construction of an adjacent single-family residential community. Although the project's land uses would be consistent with the type and character of development for the Alta Knoll Drive community, the loss of their visual open space would be an adverse significant impact.<br><br>The introduction of adjacent multiple-family housing would constitute a substantial change in the existing visual character of the project site for residents on the edge of the adjacent residential community on the east, the Ermine Street community. Even though the multiple-family housing would be situated at a substantially lower elevation than the existing homes and there would be substantial setbacks and landscaping to soften their visual effect, the site would be transformed largely from vacant mostly undeveloped property to a more urban environment. Implementation of the Proposed Project would constitute an adverse significant visual impact for these homes as it would substantially degrade the existing visual character or the quality of the site and its surroundings. | | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| ***Light and Glare***<br>New lighting associated with the Proposed Project would not be directly visible from either Plum Canyon or Bouquet Canyon, although an increase in sky "glow" may be detectible from these areas, particularly on cloudy nights. The new lighting could be perceptible from residential areas to the south; however, there is substantial distance (approximately one mile or more) between the project site and the more light sensitive residential areas in the hillsides south of the Santa Clara River wash. The mitigating effect of this distance would be expected to render this lighting impact less than significant.<br><br>The existing residential communities adjacent to the east and west sides of the project site would experience the greatest night lighting impact: the conversion of dark nighttime hillsides into an illuminated community. For residents in these areas, the Proposed Project would create new sources of substantial light. Therefore, this impact would be considered potentially significant and mitigation is required.<br><br>Glare is typically a daytime problem associated with commercial buildings constructed with highly reflective building materials. As a hillside residential development buffered by berms and substantial landscaping, the Proposed Project would not be expected to generate substantial glare. Therefore, glare impacts are expected to be less than significant. | B-1 The Project Applicant shall prepare and implement a Lighting Mitigation Plan. The Plan shall be submitted to the City of Santa Clarita Department of Planning and Economic Development for reviewed and approval prior to issuance of grading permits.<br>B-2 Project street lighting shall be the lowest intensity necessary for security and safety purposes, while still adhering to the recommended levels of the Illuminating Engineering Society of North America.<br>B-3 In order to minimize illumination wash onto adjacent areas, street lighting shall utilize non-glare fixtures directed downward onto the project site and aimed away from the off-site viewers.<br>B-4 Atmospheric light pollution shall be minimized by utilizing street lighting fixtures that cut-off light directed to the sky.<br>B-5 The project developer shall distribute information to prospective home buyers recommending the use of motion detectors for private security, rather than continuous lighting systems.<br>B-6 Project CC&Rs shall include the following restrictions on outdoor lighting for private residences:<br>• The use of exterior up lighting fixtures for building facades and trees shall be prohibited.<br>• Only down lighting for exterior-building mounted fixtures shall be permitted.<br>• Use of "glowing" fixtures that would be visible from existing communities or public | Less Than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| | roads shall be prohibited. A glowing fixture is a lantern style fixture, or any fixture that allows light through its vertical components. | |
| ***Cumulative Impacts:*** The Proposed Project represents infill development in an established urban area. There are existing residential communities to the northwest and east of the project site and residential communities under construction to the north (SunCal development) Related Project No. 4. Riverpark, combined with the Proposed Project would have the most significant visual changes to the immediate area with respect to scenic vistas, scenic resources and visual character due to proximity to the Proposed Project. The other related projects may not be as prominent visually when considered with the Proposed Project due to intervening topography. Both projects would alter, to varying degrees, Secondary Ridgelines, however, both incorporate site design and grading techniques that would minimize the disruption of the existing view corridors and scenic vistas. However, the change in visual character of the sites combined would represent a material change from an undeveloped to a developed environment that would result in a significant cumulative impact the other 11 Related Projects, significant cumulative impacts would also occur as all of these properties would involve conversion of vacant land to suburban uses. There would be a cumulative loss of vacant land as viewed from public roadways and the amount of natural vegetation and landforms would decrease overall. Therefore, an overall change in visual character with all 12 Related Project sites | None feasible for Visual Character<br><br>For Light and Glare, project mitigation would reduce project's contribution to light and glare and the increase would not be considerable and thus less than significant. | Significant and Unavoidable for Visual Character<br>Les than Significant for Scenic Vistas, Scenic Resources and Light and Glare |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| and the Related Project site would occur and is considered cumulatively significant. The Proposed Project's incremental contribution to the significant impact with respect to change in visual character would be cumulatively considerable and significant.<br><br>With respect to light and glare, mitigation measures proposed would result in less than significant impacts. | | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| AIR QUALITY | | |
| ***AQMP Consistency***<br>Projects that are consistent with the projections of employment and population forecasts identified in the Growth Management Chapter of the RCPG are considered consistent with the AQMP growth projections, since the Growth Management Chapter forms the basis of the land use and transportation control portions of the AQMP. As discussed in Section V.L. Population and Housing, implementation of the Proposed Project would not directly or indirectly induce substantial population or employment growth beyond current growth projections established by SCAG and would be consistent with the AQMP employment forecasts for the City of Santa Clarita and the Santa Clarita Valley. Therefore it would not jeopardize attainment of State and national ambient air quality standards in Los Angeles County and impacts would be less than significant. | None required. | Less than Significant |
| ***Construction Emissions***<br>Construction related daily emissions would exceed SCAQMD significance thresholds for NOx and $PM_{10}$ during the site grading phase, VOC and NOx during the peak construction phase when the school, YMCA, and first two residential phases are constructed, and NOx during the third residential development phase. Therefore, this impact would be significant regarding a substantial contribution to an existing or projected air quality violation. | C-1 The Applicant shall implement measures to reduce the emissions of pollutants generated by heavy-duty diesel-powered equipment operating at the project site throughout the project construction phases. The Applicant shall include in construction contracts the control measures required and recommended by the SCAQMD at the time of development. Examples of the types of measures currently required and recommended include the following:<br>• Keep all construction equipment in proper tune in | Significant and Unavoidable |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | accordance with manufacturer's specifications;<br>• Use late model heavy-duty diesel-powered equipment at the project site to the extent that it is readily available in the South Coast Air Basin;<br>• Use diesel-powered equipment that has been retrofitted with after-treatment products (e.g., engine catalysts or cooled exhaust gas recirculation technology) to the extent that it is readily available in the South Coast Air Basin;<br>• Use low-emission diesel fuel for all heavy-duty diesel-powered equipment operating and refueling at the project site to the extent that it is readily available and cost effective in the South Coast Air Basin (this does not apply to diesel-powered trucks traveling to and from the site);<br>• Utilize alternative fuel construction equipment (i.e., compressed natural gas, liquid petroleum gas, and unleaded gasoline) to the extent that the equipment is readily available and cost effective in the South Coast Air Basin;<br>• Limit truck and equipment idling time to five minutes or less;<br>• Rely on the electricity infrastructure surrounding the construction sites rather than electrical generators powered by internal combustion engines to the extent feasible.<br>• The following measures are recommended to reduce the potential emissions associated with | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | operational activities to the maximum extent feasible. | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| ***Daily Operational Emissions***<br>The Proposed Project would generate daily emissions that exceed the thresholds of significance for VOC, NOx, and CO recommended by the SCAQMD during both the summertime smog season and wintertime non-smog season. This is a significant impact regarding a substantial contribution to an existing or projected air quality violation. | C-2 The Applicant shall include in construction contracts the following requirements or measures shown to be equally effective:<br>• Use solar or low-emission water heaters in the residential, school, and YMCA buildings.<br>• Provide energy-efficient heating, cooling, and other appliances, such as cooking equipment, refrigerators, and dishwashers.<br>• Provide energy-efficient and automated controls for air conditioning units.<br>• Install ozone destruction catalyst on air conditioning systems, in consultation with the SCAQMD.<br>• Use light colored roof materials to reflect heat.<br>• Install only gas-burning fireplaces in the residential units. Wood-burning fireplaces shall not be constructed.<br>• Require that commercial landscapers providing services at the project site use electric or battery-powered equipment, or other internal combustion equipment that is either certified by the California Air Resources Board or is three years old or less at the time of use, to the extent that such equipment is reasonably available and competitively priced in Los Angeles County. | Significant and Unavoidable |
| ***Localized CO Concentrations***<br>Future CO concentrations near the studied intersections would not | None required. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| exceed the national and State ambient air quality standards for CO. Therefore, implementation of the Proposed Project and cumulative development would not expose any sensitive receptors located in close proximity to these intersections to substantial pollutant concentrations. This would be a less-than-significant impact regarding the exposure sensitive receptors to substantial pollutant concentrations. | | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| ***Toxic Air Contaminants***<br>Toxic or carcinogenic air pollutants are not expected to occur in any meaningful amounts in conjunction with operation of the proposed land uses at the project site. Only small quantities of common forms of hazardous or toxic substances, such as cleaning agents, which are typically used or stored in conjunction with residential and educational uses, would be present. Most uses of such substances would occur indoors. Based on the common uses expected on the site, any emission would be minor. Impacts would be a less-than-significant impact regarding the exposure sensitive receptors to substantial pollutant concentrations. | None required. | Less than Significant |
| ***Airborne Odors***<br>Potential operational airborne odors could result from cooking activities associated with the new residential units and school. These odors would be similar to existing residential uses in the local vicinity and would be confined to the immediate vicinity of the new buildings. Therefore, implementation of the Proposed Project is not expected to create objectionable odors affecting a substantial number of people. This is a less-than-significant impact. | None required. | No Impact |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| **Cumulative Impacts**<br>As long as growth in the Basin is within the projections for growth identified in the Growth Management Chapter of the RCPG, implementation of the 2003 AQMP will not be obstructed by such growth. As growth in the City of Santa Clarita and Santa Clarita Valley has not exceeded these projections, this impact would not be significant.<br><br>Because the Basin is currently in nonattainment for ozone, CO, and $PM_{10}$, related projects could exceed an air quality standard or contribute a substantial increase to an existing or projected air quality exceedance. Construction related daily emissions associated with project development would exceed SCAQMD significance thresholds for NOx and $PM_{10}$ during the site grading phase, VOC and NOx during the peak construction phase when the school, YMCA, and first two residential phases are constructed, and NOx during the third residential development phase. Therefore, the emissions generated by project construction would be cumulatively considerable regarding a substantial contribution to an existing or projected air quality violation. Operation of the Proposed Project would also generate operational emissions of VOC, NOx, and CO that exceed the SCAQMD's recommended thresholds. These emissions would, therefore, also be cumulatively considerable and significant.<br><br>Cumulative development would not have a significant impact in terms of exposure of sensitive receptors to substantial toxic pollutant concentrations or the creation of objectionable odors | None feasible. | Significant and Unavoidable |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| affecting a substantial number of people. Projects projected to be built in the vicinity of the Proposed Project site include residential and commercial developments. The odors would be similar to existing residential uses in the vicinity and would be confined to the immediate vicinity of the new buildings. As analyzed above in this section, the project's contribution to odor impacts would not be cumulatively considerable. | | |
| **BIOLOGICAL RESOURCES** | | |
| ***Native Plant Communities***<br>Coastal Sage Scrub<br><br>The Proposed Project site includes a total of approximately 100.07 acres of Coastal Sage Scrub (CSS). Grading for the Proposed Project would permanently impact 86.00 acres of CSS, which includes 0.70 acres of fuel modification impacts. The remaining 14.07 acres will be retained within Natural Open Space. The total loss represents about 86 percent of this habitat type on the site and would be considered a significant impact prior to mitigation. In addition, The Keystone site is within an area designated as critical habitat for the federally listed threatened coastal California gnatcatcher and CSS is considered to be a Primary Constituent Element (PCE) that could provide for breeding, foraging and dispersal for this species. The loss of CSS, because it is within designated critical habitat and would be considered to be a PCE, and the loss would be a significant impact | D-1 The project will impact 85.3 acres of coastal sage scrub, a special-status vegetation community and which is also within a designated critical habitat unit for the coastal California gnatcatcher. The loss of 85.3 acres of coastal sage scrub is considered a significant impact before mitigation. Mitigation would consist of restoration or purchase of 85.3 acres to replace the lost habitat or mitigation as determined by USFWS in conjunction with Mitigation Measure D-10. | Less than Significant |
| Chaparral | D-2 The project will impact 53.13 acres of chaparral, which is | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| The Proposed Project site includes a total of approximately 85.18 acres of Chaparral. Grading for the Proposed Project would permanently impact 57.85 acres of chaparral, which includes approximately 4.72 acres of fuel modification impacts. The remaining 27.33 acres will be retained within Natural Open Space. The total loss represents about 67.9 percent of this habitat type on the site. While chaparral is widespread and common and has no designation in the California Natural Diversity Database as a special-status habitat. The project site is within an areas designated as critical habitat for the federally listed threatened California Gnatcatcher and chaparral is considered to be a Primary Constituent Element (PCE) that could provide for breeding, foraging and dispersal for this species. The loss of chaparral because its within the designated critical habitat and would be considered to be a PCE, would be considered a significant impact. | also within a designated critical habitat unit for the coastal California gnatcatcher. The loss of 53.13 acres of chaparral is considered a significant impact before mitigation. Mitigation would consist of restoration or purchase of 53.13 acres to replace the lost functions of the Critical Habitat or mitigation as determined by USFWS in conjunction with Mitigation Measure D-10. | |
| Non-Native Grassland<br>The Proposed Project site totals approximately 18.42 acres of non-native grassland (NNG). Grading for the Proposed Project would permanently impact 10.81 acres of NNG, which includes approximately 1.03 acres for fuel modification. The remaining 7.61 acres will be retained within Natural Open Space. The total loss represents about 58.6 percent of this habitat type on the site. NNG is not considered a PCE of the gnatcatcher Critical Habitat and the loss of NNG would not be considered a significant impact. | None Required. | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| Southern Cottonwood-Willow Riparian Habitat<br>The Proposed Project site totals approximately 3.09 acres of southern cottonwood-willow riparian forest. Grading for the Proposed Project would permanently impact 2.44 acres of riparian forest. The remaining 0.65 acres will be retained within Natural Open Space. The loss represents about 78.9 percent of this habitat on the site and would be a significant impact. | D-3 The project will impact 2.44 acres of Southern Cottonwood-Willow Riparian Habitat, a habitat designated as sensitive in the CNDDB and that is also regulated by CDFG. The impact is therefore considered significant. The applicant shall develop a mitigation and monitoring plan to be prepared in accordance with the most Corps recent guidelines and shall receive approval of the plan by CDFG prior to impacts to jurisdictional waters on the site. A five-year monitoring plan shall be implemented as set forth in the mitigation and monitoring plan prepared for the project. | Less than Significant |
| Residential/Urban/Exotic Non-Habitat Vegetation Association<br>The Proposed Project site totals approximately 34.11 acres of residential/urban/exotic/non-habitat vegetation association. Grading for the Proposed Project would permanently impact 26.64 acres of exotic vegetation, which includes approximately 0.03 acres of fuel modification impacts. The remaining 7.47 acres will be retained within Natural Open Space. The loss represents about 78.1 percent of this habitat type on the site. Residential/Urban/Exotic vegetation is not considered a PCE of the gnatcatcher Critical Habitat and the loss of this type of land cover would not be considered significant. | None required. | Not Significant. |
| Actively Scoured Santa Clara River Bottom<br>There are no impacts to Santa Clara River wash resulting from development. This entire area will be preserved as Natural Open | None required. | Not Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| Space. | | |
| *Common Wildlife*<br>Construction activity and grading operations, associated with development of the Proposed Project would temporarily disturb common wildlife species on that occupy the site. Many mobile species (e.g., avifauna) would be expected to relocate to other areas of similar habitat within the vicinity of the site. Because of the relatively common character and widespread distribution of many or most of the wildlife species that would be displaced or lost as a result of construction activities, such impacts are not considered significant.<br><br>It should be noted that in the absence of mitigation, a number of bird species could be adversely affected as a result of implementation of the Proposed Project. The Proposed Project includes removal of mature trees and shrubs from the property. Construction-related activities could result in the direct loss of active nests or the abandonment of active nests by adult birds during the nesting season. The Migratory Bird Treaty and the California Fish and Game Code prohibit the take — defined as destroy, harm, harass, etc.— bird nest with eggs or young. | (See Measures D-5 and D-6) | Less than Significant |
| *Special Status Plant and Wildlife Resources*<br>Special-Status Plant Species<br>Oak Trees<br>Of the eight oak trees found within the project study area, five oaks are located within the project site boundaries, east of the LA DWP | D-4 While the majority of oak trees on the site will be retained in place, three oak trees (designated O-1, O-2, and O-8 in the TLC report) would be removed during grading: one (O-8) would be removed due to project construction and two would be removed due to construction of the Golden | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| right-of-way. Oak tree number 0-8, within the project site boundaries, would be removed during grading of a slope in Lot 115. The remaining four oak trees (O-3, O-4, O-5 and O-7) that are clustered together immediately adjacent to the right-of-way would be preserved in situ in an open space area not proposed for development.<br><br>The remaining three oak trees are situated outside the project site boundaries. Two of these trees (O-2 and O-6) are located in close proximity to the future alignment of the Golden Valley Road extension to Newhall Ranch Road. The project applicant would construct the road as its necessary to provide project site access. One of these trees (O-1) would be preserved in situ as it would not be within the roadway right-of-way.<br><br>Three oak trees (O-2, O-6 and O-8) would be removed by construction of the Proposed Project and the Golden Valley Road extension. | Valley Road extension from the project site boundary to Newhall Ranch Road. Appropriate approvals shall be obtained prior to oak trees being removed, subject to the Oak Tree Preservation Ordinance (Ordinance 89-1) and the City of Santa Clarita Oak Tree Preservation and maintenance Guidelines. The applicant shall develop a detailed mitigation program for approval by the City in accordance with the Ordinance. In addition, and prior to grading, oak trees near construction/grading area that will not be removed and will be protected during the grading and construction phases of the project by appropriate fencing that extends 5 feet beyond the tree canopy's dripline, or 15 feet from the trunk, whichever is greater.<br><br>Equipment damage to the limbs, trunks and roots must be avoided. Even slight trunk injuries can result in long-term, life threatening pathogenic maladies. No storage of equipment or debris within the Protective Zone (drip line plus 5 feet) will be allowed. No dumping of construction wastewater i.e., paint, stucco, concrete, clean-up, etc. Within Protective Zones, Generally, fencing shall be placed at the Protective Zone of any oak or groups of oaks within 50 feet of proposed construction activity. Protective Fencing must remain in place during construction projects and shall not be moved or removed without prior written approval from the Department of Planning and Economic Development under the direct supervision of the Project Consulting Arborist. | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | Protective Fencing shall be a least 4 feet in height with a visible sign attached a 50 feet intervals which reads: (WARNING- THIS FENCE IS FOR THE PROTECTION OF THIS TREE AND SHALL NOT BE REMOVED OR RELOCATED WITHOUT WRITTEN AUTHORIZATION FROM THE CITY OF SANTA CLARITA PLANNING AND ECONOMIC DEVELOPMENT DEPARTMENT)<br><br>Care should be taken to avoid placing any sprinklers within watering distance to the trunk of an oak tree. Generally, sprinklers should not reach within 15 feet of a mature oak trunk. Grass or ground covers must never be planted next to the trunks. Too much moisture near the base of an oak is generally believed to be their leading cause of death in residential settings. Oak Root Fungus is the result of over-watering. Oak trees survive and thrive on annual rainfall alone and generally do not need supplemental irrigation except during periods of drought. Watering should take place at or near the drip line. Landscape plans should leave the area within the drip line of an oak tree in a native or natural setting.<br><br>Care must be taken to limit grade changes near the trunk areas. The grade should not be lowered or raised around the trunks of trees. This can lead to plant stress from oxygen deprivation or Oak Root Fungus at the root collar. | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | Protective fencing shall be installed around all oaks not listed for removal. Place protective fencing at the Protected Zone (PZ) as shown on the TLM. The fencing can be repositioned as needed to allow for grading near the oaks listed as "impacted". The project arborist must be present during the fence placement. Final fencing locations shall be inspected by the City prior to the commencement of development activities. Regular inspections of this fencing shall occur during site development.<br><br>An Oak Tree Information Packet including the City of Santa Clarita Oak Tree Protection and Preservation Guidelines must be available on site during construction. The property owner and contractor should be familiar with the contents of these documents.<br><br>Vehicle travel along dirt roadways to and from the site may create a heavy coating of dust on the foliage of nearby oaks. These oaks should be hosed off periodically during construction activities.<br><br>All work performed within the Protective Zone (drip line plus 5 feet) of any oak shall be accomplished by utilizing hand tools only and must be 'monitored' by the projects Oak Tree Consultant. | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | All roots over 1.5-inch diameter will be clean cut at a 45-degree angle and treated by the Consulting Arborist.<br><br>No oaks outside the property line (except for two oaks to be removed for construction of Golden Valley Road) are to be impacted by this construction project.<br><br>The leaf-litter build-up under the canopies of the oaks on this site is ideal for healthy tree growth and root development. Do not alter or remove if possible. A 3-inch layer of mulch may be advisable in settings where leaf-little has been lost.<br><br>Do not remove the aluminum tags numbering each oak on this site.<br><br>No construction materials are to be stored or discarded within the PZ of any oak. Rinse water, concrete residue, liquid contaminates (paint, thinners, gasoline, oils, etc.) of any type shall not be deposited in any form at the base of an oak.<br><br>No vehicles shall be parked within the PZ of an oak. No construction vehicles are to be parked under the shade (within the PZ) of an oak. | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| *Special-Status Wildlife*<br>Species Observed in the Site<br>The Western spadefoot toad is a California Species of Special Concern and Federal Species of Concern and a single individual was observed on the project site during the 2003-focused survey. The area where the single individual was detected is located in an area proposed for development. However, because only a single individual was detected, the potential loss would not be considered a significant impact.<br><br>The Cooper's hawk is California Species of Special Concern that was occasionally observed foraging or flying over the site. No nesting was detected and potential breeding areas on the site are very limited. Development of the site would not result in significant impacts to the Cooper's hawk.<br><br>Bell's sage sparrow is a Federal Species of Concern and is still common throughout the region. One location for this species was observed during a number of survey visits. Breeding was not detected. Because this species is still common and only one occurrence would be affected by the project, the potential impact would not be considered significant.<br><br>The yellow warbler is a California Species of Special Concern that was observed on the site on two occasions. This species is still widespread and common in the region. No breeding was detected. Development of the site would not result in significant impacts to the | None required. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| yellow warbler.<br><br>The yellow-breasted chat is a California Species of Special Concern that was observed on the site on six occasions. This species is still widespread and common in the region. No breeding was detected. Development of the site would not result in significant impacts to the yellow-breasted chat.<br><br>The loggerhead shrike is California Species of Special Concern and Federal Species of Concern that was observed onsite on multiple occasions and constitutes a single occurrence. This species is still widespread and common in the region. No breeding was detected. Development of the site would not result in significant impacts to the loggerhead shrike. | | |
| *Migratory Bird Treaty Act Compliance*<br>Pursuant to the federal Migratory Bird Treaty Act, it is unlawful to "take" (i.e., capture, kill, pursue, or possess) migratory birds or their nests. Removal of vegetation associated with project implementation should not take place during the nesting season for most birds (January 31 to August 1) and for migratory birds (March 15 – August 15). The loss of an active nest of a migratory bird would be significant. With implementation of the recommended mitigation, this potential impact would be reduced to less-than-significant. | D-5 If grubbing or clearing of vegetation is scheduled to occur during the nesting season (January 31 to August 1), then prior to issuance of grading permits the project applicant shall have a qualified biologist survey the project site for the presence of any occupied raptor nests. If such a nest is found, then no construction work shall occur within a 300-foot radius from the nest until the nestlings have fledged, or as directed by the biological monitor to ensure compliance with Section 3503.5 of the California Fish and Game Code.<br><br>D-6 If grubbing or clearing of vegetation is scheduled to take place during the nesting season for migratory birds (March | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | 15-August 15), then three days prior to issuance of grading permits, the Project Applicant shall have a qualified biologist survey impact areas for the presence of occupied migratory bird nests. If active nests of migratory birds are located, then no construction work shall occur within a 300-foot radius from the nest until the nestlings have fledged, or as directed by the biological monitor. | |
| *Jurisdictional Resources*<br>Impacts to Corps Jurisdiction<br>Grading of the project would result in impacts to 1.22 acres of Waters of the United States which less than 0.01 acre consists of jurisdictional wetlands. The loss of 1.22 acres of Waters of the United States is considered a significant impact. | D-7 The applicant shall obtain a Section 404 Permit from the Corps prior to discharging fill into waters of the United States. The loss of 1.22 acres of waters of the United States shall be mitigated at a minimum replacement of 1:1 on the project site or in the vicinity of the site in the Santa Clara River watershed as determined through processing of the Section 404 Permit. The applicant shall develop a mitigation and monitoring plan prepared in accordance with the most recent guidelines prepared by the Corps and shall receive approval of the plan prior to impacts to jurisdictional waters on the site. A five-year monitoring plan shall be implemented as set forth in the mitigation and monitoring plan prepared for the project. | Less than Significant |
| Impacts to CDFG Jurisdiction<br>Grading for the project would result in impacts to 4.26 acres of CDFG jurisdictional streambeds is considered a significant impact. | D-8 The applicant shall obtain a Section 1602 Streambed Alteration Agreement from CDFG prior to impacting waters of the State. The loss of 4.26 acres of CDFG jurisdictional streambeds shall be mitigated at a minimum | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | replacement of 1:1 on the project site or in the vicinity of the site in the Santa Clara River watershed or as determined in the Streambed Alteration Agreement. The applicant shall development a mitigation and monitoring plan prepared in accordance with the most recent guidelines prepared by the Corps and shall receive approval of the plan by CDFG prior to impacts to jurisdictional waters on the site. A five-year monitoring plan shall be implemented as set forth in the mitigation and monitoring plan prepared for the project. | |
| *Impacts on Habitat Adjacent to Santa Clara River Riparian Area*<br><br>Upland habitat within 100 feet from riparian wildlife species is necessary to maintain species diversity within the riparian ecosystem and adequately buffer this ecosystem from adjacent incompatible land uses. Temporary grading would be allowed in the 100-foot buffer if the area is revegetated with native habitats following completion of grading. With incorporation of native habitat into the 100-foot buffer area, any impacts to the Santa Clara River would be reduced to less than significant. | D-9 Temporary project grading shall be allowed within a 100 foot buffer area adjacent to the Santa Clara River Riparian Area. Upon completion of grading, the project applicant shall re-vegetate the 100-foot buffer area with native habitat. The applicant shall delineate the 100-foot buffer prior to issuance of grading permits. A palette of site-appropriate native plant species shall be submitted to the Director of Planning & Economic Development for approval prior to issuance of grading permits. | Less than Significant |
| *Significant Ecological Areas*<br>No habitat within Santa Clara River SEA will be disturbed or converted to urban uses as result of project implementation resulting in permanent impact. Grading will be occurring in | None required | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| adjacent buffer areas; however, these areas will be planted with native species and will function as buffer areas upon completion of the project. | | |
| *Coastal California Gnatcatcher Critical Habitat Unit 13*<br>Essentially, the entire Keystone site is located within Critical Habitat Unit 13 for the federally listed threatened coastal California gnatcatcher, which was not identified on the site during focused protocol surveys. Nevertheless, the 85.3 acres of CSS and 53.13 acres of chaparral on the site, totaling approximately 138.43 acres, are considered to comprise Primary Constituent Elements (PCEs) that could potentially provide for breeding, foraging and dispersal for this species. As noted under plant communities above, the loss of CSS and chaparral, totaling 138.43 acres combined within Critical Habitat Unit 13 would be a significant impact. | D-10 The project shall require federal permits (i.e., a Section 404 Permit from the Corps) that would further require that impacts to designated critical habitat be addressed through a Section 7 Consultation with USFWS. Specific mitigation to compensate for impacts to designated gnatcatcher critical habitat will be addressed and developed in consultation with USFWS during the Section 7 Consultation. | Less than Significant |
| | Additional Construction-Related Mitigation Measures<br>D-11 The following measures shall be implemented to minimize impacts on remaining biological resources on the site as a result of construction and grading activities and to ensure that potential impacts on these resources will remain less than significant.<br><br>A qualified biologist shall be retained, as determined by the City of Santa Clarita, as a construction monitor to ensure that incidental construction impacts on biological resources are avoided, or minimized, and to conduct pre- | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | grading field surveys for special-status plant and wildlife species that may be destroyed as a result of construction and/or site preparation activities. Responsibilities of the construction monitor include the following:<br><br>a) The construction monitor shall attend pre-grade meetings to ensure that timing/location of construction activities do not conflict with mitigation requirements (e.g. seasonal surveys for plants and wildlife).<br>b) Mark/flag the construction area in the field with contractor in accordance with the final approved grading plan. Haul roads and access roads shall only be sited within the grading areas analyzed in the project EIR.<br>c) Supervise cordoning of preserved natural areas that lie outside grading areas identified in the project EIR (e.g., with temporary fence posts and colored rope).<br>d) Conduct a field review of the staking (to be set by the surveyor) designating the limits of all construction activity. Any construction activity areas immediately adjacent to riparian areas or other special-status resources should be flagged or temporarily fenced by the monitor, at his/ her discretion.<br>e) Conduct meetings with the contractor and other key construction personnel describing the importance of restricting work to designated areas. The monitor should also discuss procedures for minimizing harm/ harassment of wildlife encountered during | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | construction.<br>f) Periodically visit the site during construction to coordinate and monitor compliance with the above provisions.<br>g) Construction personnel shall be prohibited from entry into areas outside the designated construction area, except for necessary construction related activities, such as surveying. All such construction activities shall be coordinated with the construction monitor.<br>h) Standard dust control measures shall be implemented to reduce impacts on nearby plants and wildlife. This includes replacing ground cover in disturbed areas as quickly as possible; water active sites at least twice daily; suspend all excavating and grading operations when wind speeds (as instantaneous gusts) exceed 25 mph; and restricting traffic speeds on all unpaved roads to 15 mph or less in areas within 200 feet of vegetation.<br>i) Upon completion of construction, the contractor shall be held responsible to restore any haul roads and access roads that are outside of approved grading limits. This restoration shall be done in consultation with the construction monitor. | |
| ***Operational Impacts***<br>Increased Human and Domestic Animal Presence<br>Implementation of the Proposed Project would increase human and | D-12 Pets and other domestic animals shall be prohibited with fencing and signage from the open space areas and in any revegetation areas on the project site unless restrained by | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| domestic animal presence in the area. The River already receives a certain amount of equestrian and off-road vehicle use, as well as domestic animal use. an increase in these uses as a result of project implementation, taken together, could substantially effect the quality of these areas as wildlife habitat, would potentially interfere with movement of wildlife, and would potentially reduce the population of wildlife species, including special-status bird and fish species. Therefore, the increased use of the river areas by humans and domestic animals is considered a significant impact. | leash and only in designated areas.<br><br>D-13 Fencing of sufficient height and design (i.e., ranch-rail) shall be constructed between the edge of the fuel modification zone and the river corridor to deter humans and domestic animals from entering open space habitat areas.<br><br>D-14 Native shrubs such as laurel sumac, California coffeeberry, toyon, and coast prickly-pear shall be planted along the fence to further deter access. Final fence design shall be approved by and the City Planning and Building Services Department.<br><br>D-15 Human access into the open space areas shall only occur in designated locations (i.e., existing and future trails). All motorized vehicles are prohibited from entering the preserved natural open space areas with the exception of emergency or maintenance vehicles. Applicant shall post signage reflecting the above requirement.<br><br>D-16 Prohibitions against human, domestic animal, and motorized vehicle use in preserved natural open space areas shall be established by the covenants conditions and restrictions (CC & Rs) recorded with the City Planning and Building Services Department.<br><br>D-17 Interpretative signs shall be constructed and placed in | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | appropriate areas, as determined by the City Planning and Building Services Department that explain the sensitivity of natural habitats and the need to minimize impacts on these natural areas. The signs will state that they are entering a protected natural area and that all pedestrians must remain on designated trails, all pets are to be restrained on leash, and that it is illegal to harm, remove, and/or collect native plants and animals. The project applicant shall be responsible for installation of interpretive signs and fencing. | |
| ***Lighting and Glare***<br>The development of a residential community and YMCA and junior high school would increase the number of nighttime light and glare sources on the site over current levels, which are relatively low. Because of the potential disruption to breeding and foraging behavior of wildlife species remaining on, and adjacent to, and in proximity to the project site, increased nighttime lighting and glare is considered a potentially significant impact. | D-18 All street, residential, and parking lot lighting shall be downcast luminaries or directional lighting with light patterns directed away from natural areas. Covenants, Codes and restrictions (CC&Rs) shall require the exterior lighting within the residential area be limited to low voltage unless such lights are shielded and pointed downward. | Less than Significant |
| ***Increase in Population of Non-Native Species***<br>Non-native plant and wildlife species are typically attracted to developed and urban environments and potentially displace native species because of their ability to complete more effectively for resources. However, because various levels of development essentially surround the project site, non-native and urban-adapted | D-19 The only potential impacts associated with an increase in non-native are along the interface of the Santa Clara River. Implementation of Mitigation Measures D-9 and D-17 above, would mitigate these potential impacts to a level that is less than significant. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| plant species already occur on the project site and surrounding area. Consequently, the project is not exposed. Therefore, impacts on the remaining natural areas as result of potential increases in non-native plants and wildlife resulting from project implementation are not expected to be significant. However, incorporation of native planting into buffer areas along the Santa Clara River would ensure that impacts to the river are less than significant.<br><br>**Cumulative Impacts**<br><br>Because of the overall low value of the biological resources on the site, the proposed Keystone project's contribution to the regional loss would not be substantial. However, significant impacts to Coastal Sage Scrub, Chaparral, Southern Cottonwood-Willow Riparian Forest and individual oak trees have been determined and the loss of these habitats with project and related project implementation would add to the cumulative loss in the regions. With implementation of the mitigation for direct habitat loss would be fully compensated and the cumulative impacts would also be reduced to a less-than significant level as set forth mitigation measures D-1, D-2, D-3, and D-5.<br><br>Cumulative impacts to Gnatcatcher Critical Habitat Unit 13 would be mitigated to a less than significant level as set forth in mitigation measure D-1, D-2, and D-4. The cumulative loss of aquatic resources subject to the jurisdiction of the Corps and CDFG would be mitigated with the project mitigation measure D-8. All potential | None required | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| cumulative impacts to biological resources would be mitigated to a less-than-significant level with implementation of the mitigation measures set forth above. | | |
| **CULTURAL RESOURCES** | | |
| ***Historical:***<br>According to the Phase I that was prepared for the project, although no evidence of historical resources was found on the project site, the project site is moderately sensitive for historical resources and unknown resources could be uncovered during project construction. If proper care is not taken during grading and excavation activities, these unknown resources could be damaged or destroyed. Therefore, project impacts on unknown historical resources would be significant. | E.1-1 Prior to excavation and construction on the Proposed Project site, the prime construction contractor and any subcontractor(s) shall be cautioned on the legal and/or regulatory implications of knowingly destroying cultural resources or removing artifacts, human remains, bottles, and other cultural materials from the project site.<br><br>E.1-2 If during any phase of project construction, any cultural materials are encountered, construction activities within a fifty-meter radius shall be halted immediately, and the project applicant shall notify the City. A qualified historic archaeologist (as approved by the City) shall be retained by the project applicant and shall be allowed to conduct a more detailed inspection and examination of the exposed cultural materials. During this time, excavation and construction would not be allowed in the immediate vicinity of the find. However, those activities could continue in other areas of the project site. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | E.1-3 If any find were determined to be significant by the qualified historic archaeologist, the City, and the qualified historic archaeologist would meet to determine the appropriate course of action.<br><br>E.1-4 All cultural materials recovered from the site would be subject to scientific analysis, professional museum curation, and a report prepared according to current professional standards. | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| ***Prehistoric Archaeological Resources***<br>One prehistoric archaeological site (CA-LAN-0295) and two prehistoric isolates have been recorded within a one mile radius of the project site. According to the Phase I that was prepared for the project, the site appears to be clear of any known, potentially significant resources and not likely to yield buried deposits. Given the archaeological-sensitivity of the area, it is possible that during the project's construction phase, unknown prehistoric archaeological resources could be encountered. Without proper care during grading and excavation, unknown resources could be damaged or destroyed. Therefore, project impacts on unknown prehistoric archaeological resources would be significant. | Mitigation measures E.1-1 through E.1-4, listed under Cultural Resources, Historical Resources above, for the impacts to unknown resources would also be applicable to unknown prehistoric archaeological historic archaeological resources. | Less than Significant |
| ***Human Remains***<br>No evidence has been uncovered that the project would disturb any human remains. Contact with the Native American Heritage Commission resulted in no written comments and no specific concerns with respect to potential resources on the site. However, it is possible during the project's construction phase that human remains could be uncovered. Therefore, project impacts on unknown human remains would be significant. | E.2-1 If human remains are discovered at the project site during construction, work at the specific construction site at which the remains have been uncovered shall be suspended, and the City of Santa Clarita Department of Planning and Economic Development and County coroner shall be immediately notified. If the remains are determined by the County coroner to be Native American, the Native American Heritage Commission (NAHC) shall be notified within 24 hours, and the guidelines of the NAHC shall be adhered to in the treatment and disposition of the remains. | Less than Significant |
| ***Paleontological resources:***<br>Although earth-moving activities would be relatively short term, some fossil remains, unrecorded fossil sites, associated specimen | E.3-1 Prior to construction, the project applicant shall retain the services of a qualified vertebrate paleontologist approved by the City of Santa Clarita and the Los Angeles County | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| data, and corresponding geologic and geographic site data, and the fossil-bearing strata could be lost. The potential loss of these paleontological resources would be significant. Therefore, project impacts on paleontological resources would be significant. | Vertebrate Paleontology Department (LACMVP) to implement the mitigation program during earth-moving activities in the parcel.<br><br>E.3-2 The paleontologist shall develop a formal agreement with a recognized museum repository, such as the LACMVP, regarding final disposition and permanent storage and maintenance of any fossil remains and associated specimen data and corresponding geologic and geographic site data that might be recovered as a result of the mitigation program, and the level of treatment (preparation, identification, curation, cataloguing) of the remains that would be required before the entire mitigation program fossil collection would be accepted by the repository for storage.<br><br>E.3-3 Prior to the start of any earth-moving activity associated with development of the parcel, the paleontologist and/or monitor shall conduct an intensive survey of the parcel, including those areas that would be buried but not otherwise disturbed by these activities. The survey, particularly with regard to areas of the parcel underlain by the Saugus Formation, shall allow for the discovery of any unrecorded fossil site and the recovery the fossil remains, the recording of associated specimen data and corresponding geologic and geographic site data, and the recognition of fine-grained strata suitable for containing smaller vertebrate fossil remains. The recovery of fossil | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | remains during the survey might reduce the potential for a delay in earth-moving activities.<br><br>E.3-4 The paleontologist or monitor shall coordinate with the appropriate grading contractor personnel to provide information regarding lead agency requirements for the protection of paleontological resources. Contractor personnel also shall be briefed on procedures to be followed in the event that a fossil site or remains are encountered by earth-moving activities, particularly when the monitor is not on site. The briefing shall be presented to new contractor personnel as necessary. Names and telephone numbers of the monitor and other appropriate mitigation program personnel shall be provided to the appropriate contractor personnel.<br><br>E.3-5 Earth-moving activities shall be monitored by the monitor only in those areas of the parcel where these activities would disturb previously undisturbed strata. Monitoring shall be conducted on a full-time basis in areas underlain by Saugus Formation, half time where underlain by the low terrace remnants, and quarter time where underlain by the high terrace deposits, younger alluvium, and stream channel deposits (monitoring would not be conducted in areas underlain by younger alluvium or stream channel deposits, unless and until these activities have reached a depth at least 5 feet below grade, or in areas where exposed strata would be buried, | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | but not otherwise disturbed). If fossil remains are encountered by these activities, monitoring shall be increased to full or half time, as appropriate, at least in the vicinity of the fossil site where the area is underlain by the fossil-bearing rock unit. With City of Santa Clarita approval, if no fossil remains are found once 50 percent of earth-moving activities have been completed in an area underlain by a particular rock unit, monitoring may be reduced or suspended in that area.<br>Monitoring shall consist of visually inspecting debris piles and freshly exposed strata for larger fossil remains, and periodically dry test screening sediment, rock, and debris for smaller fossil remains. As soon as practicable, the monitor shall recover all vertebrate fossil specimens, a representative sample of invertebrate or plant fossils, or any fossiliferous rock sample that can be recovered easily. If recovery of a large or unusually productive fossil occurrence is warranted, earth-moving activities shall be diverted temporarily around the fossil site and a recovery crew shall be mobilized as necessary to remove the occurrence as quickly as possible. If not on site when a fossil occurrence is uncovered by these activities, the activities shall be diverted temporarily around the fossil site and the monitor called to the site to evaluate and, if warranted, remove the occurrence. If the fossil site is determined too unproductive or the fossil remains not worthy of recovery, no further action shall be taken to preserve the fossil site or remains, and earth-moving | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | activities would be allowed to proceed through the site immediately. The location and proper geologic context of any fossil occurrence shall be documented, as appropriate. Any recovered rock sample shall be processed to allow for the recovery of smaller fossil remains.<br>Rock samples shall be processed to allow for the recovery of smaller fossil remains that normally are too small to be observed by the monitor. No more than 6,000 pounds (12,000 pounds total) of rock shall be processed from either the Saugus Formation or the low terrace remnants.<br><br>E.3-6 All fossil specimens recovered from the parcel as a result of the mitigation program, including those recovered as the result of processing fossiliferous rock samples, shall be treated (prepared, identified, curated, catalogued) in accordance with designated museum repository requirements. Rock samples from the Saugus Formation and older alluvium shall be submitted to commercial laboratories for microfossil, pollen, or radiometric dating analysis.<br><br>E.3-7 The monitor shall maintain daily monitoring logs that include the particular tasks accomplished, the earth-moving activity monitored, the location where monitoring was conducted, the rock unit encountered, fossil specimens recovered, and associated specimen data | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | and corresponding geologic and geographic site data. A final technical report of results and findings shall be prepared by the paleontologist in accordance with any City of Santa Clarita requirement. | |
| ***Cumulative Impacts:*** There are no historical resources located on the project site. One prehistoric archaeological site (CA-LAN-0295), two prehistoric isolates, and seven historical archaeological sites (CA-LAN-2105, CA-LAN-2132, and CA-LAN-2040 through -2044) have been recorded within one mile of the project area and there is further potential that one or more of the related projects might encounter archaeological resources during the course of development. It is anticipated that historic, archeological or paleontological resources that are potentially affected would be subject to the requirements of CEQA. It is further anticipated that the effects of cumulative development on such resources would be mitigated to the extent feasible in accordance with CEQA and other applicable legal requirements. Consequently, cumulative impacts are expected to be less than significant and thus, when considered in conjunction with the Proposed Project would not be cumulatively considerable. | None required. | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| GEOLOGY AND SOILS | | |
| ***Earthquakes, Landslides, Mudslides, Ground Failure, or Similar Hazards*** The Geologic and Geotechnical Report prepared for the project site determined that impacts exposing people or property to geologic hazards related to earthquakes, landslides/mudslides, ground failure associated with liquefaction, transition lots, groundwater and soil corrosivity would be less than significant with incorporation of the required mitigation measures. | The Proposed Project may result in potential impacts associated with geotechnical resources prior to mitigation. Therefore, the Project Applicant has committed to implementing the following mitigation measures for the Proposed Project to ensure that future development of the project site is safe from geotechnical hazards (earthquakes, landslides, mudslides, ground failure or similar hazards), wind or water erosion of soils, unstable earth conditions in geologic substructure and that it would not adversely affect adjacent properties.<br>General<br>F-1 All project site development shall be performed according to the recommendations identified in the referenced report, (Allan E. Seward Engineering Geology, 2004).<br>F-2 Mitigation measures for geotechnical resources shall be implemented so as not to conflict with mitigation measures as section set forth in Section V.D, Biological Resources, of this EIR. | Less than Significant |
| ***Wind or Water Erosion of Soils*** Wind and water erosion of the project site would increase during construction activities unless mitigated, and this would result in a significant construction-related impact. With proposed mitigation, impacts would be less than significant.<br>Once developed, site erosion and sedimentation would decrease | ***Drainage Control***<br>F-25 Wherever groundwater seepage is observed, the condition shall be evaluated by the Engineering Geologist and Geotechnical Engineer prior to covering with fill material.<br>F-26 Surface drainage control design shall include provisions for positive surface gradients to ensure that surface runoff | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| substantially compared to existing conditions because the project site would be covered with non-erosive surfaces, including pavement, structures, and permanent vegetation, all which would reduce the amount of exposed soil subject to wind and water erosion. Also, implementation of the existing provisions in the City's grading requirements for planting and irrigation of constructed slopes in conjunction with drainage recommendations would provide sufficient mitigation against potential erosion within the project site. As a result, long-term project impacts would be less than significant. | is not permitted to pond, particularly above slopes or adjacent to building foundations or slabs. Surface runoff shall be directed away from slopes and foundations and collected in lined ditches or drainage swales via non-erodible drainage devices, which shall discharge to paved roadways or existing watercourses. If these facilities discharge onto natural ground, means shall be provided, as directed by the project Civil Engineer, to control erosion and to create sheet flow.<br><br>F-27 It should be expected that, even with the construction of carefully planned and designed erosion control measures, some erosion may occur during the first few wet seasons after the project is completed. Site grading should be inspected, particularly after heavy, prolonged rainfall, to identify erosion areas at an early stage. Maintenance work shall be done as soon as practical to repair these areas and prevent their enlargement.<br><br>F-28 Planting and irrigation standards within the City of Santa Clarita Grading Code shall be adhered to in order to prevent soil erosion.<br><br>F-29 Fill slopes and stability fills, as applicable, shall be provided with subsurface drainage as necessary for stability as determined by the project Geologist/Geotechnical Consultant. A typical backdrain detail is shown on Figure E7, Appendix E of the | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | referenced report (Allan E. Seward Engineering Geology, Inc, 2004). Also, subdrains along the bottom of canyon fills shall be constructed. A typical canyon subdrain detail is presented on Figure E9 of the referenced report.<br><br>F-30 All final grades shall be sloped away from the building foundations to allow rapid removal of surface water runoff. No ponding of water shall be allowed adjacent to the foundations. Plants and other landscaped vegetation requiring excessive watering shall be avoided adjacent to the building foundations. Should landscaping be constructed, an effective water-tight barrier shall be provided to prevent water from affecting the building foundations.<br><br>**Corrosivity and Chemical Attack Considerations**<br>F-41 On-site soils classify as severely corrosive to corrosive to buried metals per County of Los Angeles classification. Sulfate concentrations are negligible per UBC (1997) classification, and pH was near-neutral (reported as 7.2 in the referenced report, Allan E. Seward Engineering Geology, Inc., 2004). Pending additional testing, either Type I or II cement may be considered for use in concrete placed in contact with the ground. Mitigating measures for soil corrosivity shall be finalized by the Project Engineer based on additional confirmatory tests that shall be performed at the Grading Plan stage. Final recommendations for concrete shall be in accordance with | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | the latest UBC requirements, and a corrosion specialist shall provide mitigating recommendations for potential corrosion of metals in contact with on-site soils prior to issuance of a Grading Permit. | |
| ***Unstable Earth Condition or Changes in Geologic Substructure*** Development over the existing undocumented fill would result in a significant geotechnical impact unless mitigated. With proposed mitigation, impacts would be less than significant. | ***Landslides*** F-18 Three landslides are located within or in the vicinity of the proposed development area of the project. These landslides shall be mitigated as recommended in Table 1 of Geologic and Geotechnical Report – Addendum No. 1 Revised Tentative Tract Map of the referenced report, (Allan E. Seward Engineering Geology, 2004).<br><br>F-19 Landslides Qls-1, Qls-2 and Qls-3 shown in figure 4.1-1 should be included on the Final Map as Restricted Use Areas.<br><br>***Proposed Cut-Slopes*** F-20 Eighteen proposed cut-slopes ranging in height from 25 feet to 120 feet are proposed on the project site and are designated as CS-1 through CS-18. Recommended mitigation, if necessary, for each slope as presented in Cut-Slope Summary (Table 2.1 of the referenced report, Allan E. Seward Engineering Geology, Inc., 2004), shall be followed. This determination shall be made by the Geologist/Geotechnical Consultant prior to grading activities. It has been conservatively assumed for the purposes of stability analysis that weak bedding planes | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | may occur anywhere in the proposed cut-slopes. If any of the smaller proposed cut-slopes (less than 25± feet in height) have adverse geologic grading configurations (fill over cut), they shall be mitigated, if necessary, with a standard 15- to 20-foot wide key (depending on the proposed cut-slope height) and benching similar to a Stability Fill. A "Typical Fill above Cut-Slope" detail is shown on Figure E8 within Appendix E of the referenced report, (Allan E. Seward Engineering Geology, 2004). This determination shall be made by the project Geologist/Geotechnical Consultant prior to grading activities.<br><br>F-21 All permanent cut-slopes shall be constructed at a slope ratio not steeper than 2:1 (h:v). All permanent cut-slopes exposing Terrace Deposits or Alluvium shall be constructed as a stability fill. Temporary cut slopes in competent rock may be constructed as steep as 1.5:1 (h:v). Potential unstable subsurface conditions exposed during construction, such as adverse bedding, joint planes, zones of weakness or exposed seepage, may require either flatter slopes than specified above or construction of benches. An Engineering Geologist shall observe all backcuts during the grading operations and provide appropriate recommendations, if necessary.<br><br>***Natural Slopes*** | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | F-22 Natural slopes within the proposed Tentative Tract 60258 have gradients ranging from 5:1 (h:v) to 1.1:1 (h:v). A 75-foot high approximately 1:1 (h:v) gradient slope located westerly of Lot 99 within the DWP easement was identified by the referenced report, (Allan E. Seward Engineering Geology, 2004) as the most critical slope. The referenced report illustrates the geologic conditions of this slope on Section 13 - 13' and provides slope stability analysis indicating that this natural slope satisfies the City of Santa Clarita factor of Safety requirements. All natural slopes that are relatively steep and have accumulations of soil and slopewash are prone to debris flow hazard.<br><br>F-23 A fill over natural condition is proposed along the southern edge of the proposed school site (Lot 102) above the Santa Clara River. The natural slope is approximately 90-feet in height with gradients up to 1.1:1 (h:v). A fill slope up to 40 feet in height is proposed to ascend above the natural slope. The referenced report, (Allan E. Seward Engineering Geology, Inc., 2004), recommends a twenty foot horizontal bench to set back the fill slope from the descending natural slope. The horizontal bench is recommended to extend laterally a distance of approximately 450 feet. The recommended bench is color coded yellow on the Geologic/Geotechnical Map as well as on Cross Section 3-3' Plate II within the referenced report, (Allan E. Seward Engineering Geology, Inc., 2004). | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | ***Exploratory Trench and Boring Backfill***<br>F-24 All of the exploratory trenches and borings previously excavated for this project shall be overexcavated and backfilled with compacted fill in accordance with the earthworks recommendations of the referenced report, (Allan E. Seward Engineering Geology, Inc., 2004). | |
| | **Earthwork**<br>F-3 All grading shall be accomplished under the observation and testing of the Project Soils Engineer, Engineering Geologist and/or their authorized representatives in accordance with the recommendations contained herein, the current Uniform Building Code requirements and "Recommended Earthwork Specifications" as presented in Appendix E of the referenced report. (Allan E. Seward Engineering Geology, 2004).<br><br>***Site Preparation***<br>F-4 During site preparation, the site shall be cleared and stripped of organics (vegetation), topsoil, roots, undocumented artificial fill, rubble, construction debris and other unsuitable materials, as applicable, and the site shall be graded to provide a firm base for compacted fill. All organics shall be removed from the site for proper disposal. The Geotechnical Engineer and/or his representatives shall observe the excavated areas prior to placing compacted fill. | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | ***Removal and Benching***<br>F-5 In order to provide a uniform firm bottom prior to placing fill, all unconsolidated alluvium, slopewash, colluvial soils and severely weathered terrace deposits and bedrock shall be removed from areas to receive fill. The estimated depths of removals (excluding landslides) range from 3 to 36 feet as shown on Figure V.F-1. The exact depth and extent of necessary removals will be determined in the field during the grading operations when observations and more location specific evaluations can be performed.<br><br>F-6 All existing artificial fill (af) shall be removed and replaced with compacted fill. Removals at the locations of exploratory trenches shall be extended to the bottom of the trench backfill if the adjacent removal depths are shallower than the trench.<br><br>F-7 In areas to receive compacted fill where the surface gradient is steeper than 5:1 (h:v), the soil mantle, colluvium and unsuitable material shall be removed and such areas benched horizontally into competent material prior to or in conjunction with fill placement (see Appendix E. Fill Over Natural Slope, Figure E2 of the referenced report, Allan E. Seward Engineering Geology. 2004).<br><br>***Preparation of Bottom Areas***<br>F-8 After the ground surface to receive fill has been exposed. | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | it shall be ripped to a minimum depth of 6 inches, brought to optimum moisture content or above, thoroughly mixed to obtain a near uniform moisture condition and uniform blend of materials, and then compacted to the required relative compaction per the ASTM D 1557 laboratory maximum density.<br><br>***Dewatering During Removals***<br>F-9 Where recommended removals encounter groundwater, water levels shall be controlled by providing an adequate excavation bottom slope and sumps for pumping water out as the excavation proceeds, or groundwater may be lowered by installing shallow dewatering well points prior to grading. Partial removals of soils above the water table and soil improvement below the water table (e.g., shallow compaction grouting) may be another option. The determination as to which measures are to be used shall be made by the project Civil Engineer. Dewatering may be needed depending on the season when the removals are performed. All discharges from dewatering operations, if any, shall comply with the National Pollutant Discharge Elimination System Permit (NPDES) requirements of project construction.<br><br>***Over-Excavation***<br>F-10 A minimum five-foot thick over-excavation shall be performed on all cut-lots, transitional lots (transitions between bedrock, fill, terrace deposits and alluvium), and | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | streets. This overexcavation will result in reduction of potential differential settlements or differential material response to seismic events and provide a uniform base for structural support of buildings. If the maximum depth of fill exceeds 15 feet on a cut/fill transition lot, then the thickness of the fill cap shall be one-third of the deepest fill thickness below any proposed structure (see Appendix E, Cut Lot and Cut Fill Lot (Transitional), Figure E3, of the referenced report, Allan E. Seward Engineering Geology, 2004). If excavation of the native soils (i.e., bedrock) exposes expansive materials, then the lot over-excavation shall be deepened to at least eight feet.<br><br>***Fill Materials***<br>F-11 On-site soils that are free of debris, over-size rocks, topsoil and organic matter may be used as sources for compacted fills. Rock or similar irreducible material with a maximum dimension greater than eight inches may not be placed in the fill. Rocks or hard fragments larger than four inches shall not compose more than 25 percent of the fill and/or lift. Any large rock fragments over eight inches in size, may be incorporated into the fill as rockfill in windrows after being reduced to the specific maximum rock fill size, see Figure E4, Rock Disposal, in Appendix E of the referenced report, (Allan E. Seward Engineering Geology, 2004). Where fill depths are too shallow to allow large rock disposal, special handling or removal may be required depending upon on-site field decisions | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | made during grading operations by the project Geologist/Geotechnical Consultant see "Recommended Earthwork Specifications" in Appendix E of the referenced report, (Allan E. Seward Engineering Geology, 2004).<br><br>***Fill Compaction***<br>F-12 All fill material shall be placed in uniform lifts not exceeding eight inches in its loose state and compacted to a minimum of 90 percent relative compaction as determined based on the latest ASTM Test Designation D-1557. Additional field compaction requirements are presented in Appendix E, "Recommended Earthwork Specifications" of the referenced report (Allan E. Seward Engineering Geology, 2004). Appendix E also includes recommended specifications for placement of trench backfill.<br><br>F-13 For fills deeper than 40 feet, the portion of fill below 40 feet depth shall be compacted to a minimum of 93 percent relative compaction. These areas shall be delineated at the Grading Plan stage.<br><br>***Proposed Fill Slopes***<br>F-14 Fill slope inclinations shall not be steeper than 2:1 (h:v). The fill material within approximately one equipment width (typically 15 feet) of the slope face shall be constructed with cohesive material obtained from on-site | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | soils. The finished fill-slope face shall be constructed by over-building the slope and cutting back to the compacted fill material. Stability fills are recommended where cut-slope faces will expose fill-over bedrock, alluvium over bedrock or Quaternary terrace deposits over bedrock conditions. These fills shall be constructed with a keyway at the toe of the fill slope with a minimum equipment width, but not less than 15 feet, and a minimum depth of 3 feet into the firm undisturbed earth. Following completion of the keyway excavations, the Project Engineering Geologist shall observe and approve the keyway bottom prior to backfilling with certified engineered fill.<br><br>F-15 Where fill slopes are constructed above natural ground with a gradient of 5:1 (h:v) or steeper, all topsoil, colluvium, and unsuitable material shall be removed and a keyway shall be constructed at the toe of the fill slope with a minimum width of 15 feet, and a minimum depth of 3 feet into firm undisturbed earth (see Appendix E, Fill Slope Over Natural Slope diagram, Figure E5 of the referenced report, Allan E. Seward Engineering Geology, 2004). Following completion of the keyway excavations, the project Engineering Geologist/Geotechnical Engineer or designated representative shall observe and approve the keyway bottom prior to backfilling with compacted fill.<br><br>F-16 Where fill slopes toe out on relatively level natural ground, the removals shall be performed to a minimum | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | 1:1 (h:v) projection from the toe of slope to the recommended removal depth, (see Appendix E, Fill Slope Toeing Out on Flat Alluviated Canyon, Figure E6 of the referenced report. Allan E. Seward Engineering Geology, 2004).<br><br>F-17<br><br>Where sliver fill-slopes are proposed, the slope shall be constructed with a minimum 15-foot width Stability Fill throughout, which is keyed in at the toe of slope (see Appendix E, Stability/Buttress Fill and Backdrains Detail, Figure E7 the referenced report, Allan E. Seward Engineering Geology, 2004).<br><br>***Proposed Cut-Slopes***<br>F-20 Eighteen proposed cut-slopes ranging in height from 25 feet to 120 feet are proposed on the project site and are designated as CS-1 through CS-18. Recommended mitigation, if necessary, for each slope as presented in Cut-Slope Summary (Table 2.1 of the referenced report, Allan E. Seward Engineering Geology, Inc., 2004), shall be followed. This determination shall be made by the Geologist/Geotechnical Consultant prior to grading activities. It has been conservatively assumed for the purposes of stability analysis that weak bedding planes may occur anywhere in the proposed cut-slopes. If any of the smaller proposed cut-slopes (less than 25± feet in height) have adverse geologic grading configurations (fill over cut), they shall be mitigated, if necessary, with a | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | standard 15- to 20-foot wide key (depending on the proposed cut-slope height) and benching similar to a Stability Fill. A "Typical Fill above Cut-Slope" detail is shown on Figure E8 within Appendix E of the referenced report, (Allan E. Seward Engineering Geology, 2004). This determination shall be made by the project Geologist/Geotechnical Consultant prior to grading activities.<br><br>F-21 All permanent cut-slopes shall be constructed at a slope ratio not steeper than 2:1 (h:v). All permanent cut-slopes exposing Terrace Deposits or Alluvium shall be constructed as a stability fill. Temporary cut slopes in competent rock may be constructed as steep as 1.5:1 (h:v). Potential unstable subsurface conditions exposed during construction, such as adverse bedding, joint planes, zones of weakness or exposed seepage, may require either flatter slopes than specified above or construction of benches. An Engineering Geologist shall observe all backcuts during the grading operations and provide appropriate recommendations, if necessary.<br><br>*Natural Slopes*<br>F-22 Natural slopes within the proposed Tentative Tract 60258 have gradients ranging from 5:1 (h:v) to 1.1:1 (h:v). A 75-foot high approximately 1:1 (h:v) gradient slope | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | located westerly of Lot 99 within the DWP easement was identified by the referenced report, (Allan E. Seward Engineering Geology, 2004) as the most critical slope. The referenced report illistrates the geologic conditions of this slope on Section 13 - 13' and provides slope stability analysis indicating that this natural slope satisfies the City of Santa Clarita factor of Safety requirements. All natural slopes that are relatively steep and have accumulations of soil and slopewash are prone to debris flow hazard.<br><br>F-23 A fill over natural condition is proposed along the southern edge of the proposed school site (Lot 102) above the Santa Clara River. The natural slope is approximately 90-feet in height with gradients up to 1.1:1 (h:v). A fill slope up to 40 feet in height is proposed to ascend above the natural slope. The referenced report, (Allan E. Seward Engineering Geology, Inc., 2004), recommends a twenty foot horizontal bench to set back the fill slope from the descending natural slope. The horizontal bench is recommended to extend laterally a distance of approximately 450 feet. The recommended bench is color coded yellow on the Geologic/Geotechnical Map as well as on Cross Section 3-3' Plate II within the referenced report, (Allan E. Seward Engineering Geology, Inc., 2004).<br>***Exploratory Trench and Boring Backfill***<br>F-24 All of the exploratory trenches and borings previously excavated for this project shall be overexcavated and backfilled with compacted fill in accordance with the | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | earthworks recommendations of the referenced report. (Allan E. Seward Engineering Geology, Inc., 2004).<br><br>***Shrinkage, Bulking and Subsidence***<br>F-31 The Project Engineer shall design pad grades with sufficient flexibility to accommodate a possible shortage of fill of up to 10 percent of the total yardage graded due to potential shrinkage of fill and potential subsidence due to dewatering.<br><br>***Foundation Settlement Consideration***<br>F-32 The structural design shall include seismic geotechnical parameters in accordance with UBC requirements for Seismic Zone 4. These parameters will be provided at the Grading Plan stage.<br><br>F-33 Shallow spread footings for foundation support of residential structures can adequately be placed on compacted engineered fill as stated in Mitigation Measures V.F-13 and V.F-14. Support for heavier structures, if applicable, shall be addressed at the Grading Plan stage. Minimum specifications for continuous (wall) foundation dimensions are 12 inches wide and 12 inches deep below lowest adjacent grade for single-story residential structures. Tentatively, an allowable bearing capacity of 1,500 pounds per square-foot can be used for (minimum-sized) shallow foundations constructed in certified compacted fill. This tentative allowable bearing value | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | shall be confirmed by further field and laboratory testing by the Project Geologist of the site soils before use in design plans. Lateral resistance of footing walls shall be provided at the Grading Plan stage.<br><br>F-34 If, during grading operations, the resulting cut-fill transition is steep, as determined by the project Geologist/Geotechnical Consultant, at depth below the building area, the geometry of the transition shall be reviewed during grading operations by the Soils Engineer on a site-specific basis to evaluate the need for additional over excavation removals and/or additional foundation reinforcement. As a general guideline, steep cut/fill transitions would include slope gradients steeper than 4:1 (h:v) and overall variations in fill thickness of greater than 15 feet, which occur within 20 feet of final pad grade. The determination of need for over excavation of materials shall be guided by Figure E3 (Appendix E), "Cut Lot (Transitional)" and "Cut-Fill Lot (Transitional") of the referenced report, (Allan E. Seward Engineering Geology, Inc., 2004), which provides a foundation grading detail for locations where foundations will straddle transition zones between cut and fill materials.<br><br>F-35 To minimize significant settlements, the upper soils in areas to receive fills shall be removed and replaced with compacted fill. Some minor settlements will be expected due to loads from high fills (e.g., thicker than 30 feet). | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | Currently, locations of proposed high fills are in the vicinity of Lots 10-21, 30-34, 38, 39, 42-56, 77, 97, 99, 102, and 102A. Most of the settlements due to the load of added fill will occur during and shortly after rough grading is complete. However, since lenses of relatively compressible clayey soils exist below recommended removal depths, some of the fill settlements will not occur until the ground water table is lowered below the compressible clay lenses. Ground water table lowering is usually the result of pumping from water wells. (Note: the Proposed Project would not directly withdraw groundwater.) Alternatively, the project site may be temporarily surcharged with earth fill sufficient to simulate the load increase on the compressible clay lenses due to lowering of the ground water table, as determined by the project Geologist/Geotechnical Consultant.<br><br>F-36 At other alluvial removal areas, potential settlements in Alluvium shall be minimized by the removals and recompaction recommended in the referenced report, (Allan E. Seward Engineering Geology, Inc., 2004). Also, potential effects from localized seismically induced settlements will be attenuated by the recompacted upper layers and proposed additional fills, see Appendix C in the referenced report, (Allan E. Seward Engineering Geology, 2004).<br><br>***Excavation, Shoring and Backfill Recommendations*** | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| | F-37 Excavations deeper than 3.5 feet shall conform to safety requirements for excavations as set forth in the State Construction Safety Orders enforced by the State Division of Industrial Safety, CAL OSHA. Temporary excavations 12 feet or lower shall be no steeper than 3/4:1 (h:v). For excavations to 20 feet in height, the bottom 3.5 feet may be vertical and the upper portion between 3.5 and 20 feet shall be no steeper than 1.5:1 (h:v). Excavations not complying with these requirements shall be shored. Excavation walls in sands and dry soils shall be kept moist, but not saturated at all times.<br><br>F-38 Parameters for design of cantilever and braced shoring shall be provided at the Grading Plan stage.<br><br>F-39 The bases of excavations or trenches shall be firm and unyielding prior to foundations or utility construction. On-site materials other than topsoil or soils with roots or deleterious materials may be used for backfilling excavations. Densification (compaction) by jetting may be used for on-site clean sands or imported equivalent of coarser sand provided they have a Sand Equivalent greater than or equal to 30 as determined by ASTM D2419 test method. Specifications for placement of trench backfill shall be adhered to and are presented in Appendix E of the referenced report, (Allan E. Seward Engineering Geology, 2004). | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | ***Expansive Soils Considerations***<br>F-40 The measures presented in Table E1, Minimum Foundation and Slab Recommendations for Expansive Soils, in Appendix E of the referenced report, (Allan E. Seward Engineering Geology, 2004), shall be implemented to minimize the effects of soil expansion potential. It is anticipated that compacted fill from the on-site materials will have a very low to medium expansion potential. The expansion potential of the site soils exposed at rough grade shall be tested again after site grading is complete and the final foundation design shall be based on those expansion test results. | |
| ***Cumulative Impacts :***<br>Geotechnical impacts are site specific in nature and each development site is subject to, at minimum, uniform site development and construction standards relative to seismic and other geologic conditions that are prevalent within the locality and/or region. Therefore, impacts of cumulative development would be less than significant given known geologic considerations of the cumulative projects. | None required. | Less than Significant |
| **HAZARDS** | | |
| ***Routine Transport, Use or Disposal of Hazardous Materials/Risk of Upset***<br>*Construction*<br>The services of properly trained and qualified hazardous waste | G-1 The services of properly trained and qualified hazardous waste handlers shall be used to perform hazardous waste cleanup or abatement, transportation and disposal prior to construction and appropriate protocol shall be followed to | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| handlers shall be used to perform hazardous waste cleanup or abatement, transportation and disposal prior to construction and appropriate protocol will be followed to ensure that construction workers are not exposed to toxic substances. Therefore, hazardous materials impacts relative to exposure to hazardous substances during disposal would be less than significant with mitigation.<br><br>Oil Production Operations<br>The site assessment report indicated that the former oil well and drill site had been abandoned in 1964 in accordance with applicable regulations. However, the Phase 1 Environmental Site Assessment report did not map the exact location of the oil well and referred to the area as the "southwest" portion of the site.<br>It is recommended as mitigation that additional environmental assessment be provided documenting the exact location of the oil well. Since the oil well was abandoned in 1964 it is recommended that the well be re-abandoned to current standards. With this mitigation, impacts would be less than significant with regards to the oil well.<br><br>Previous Agricultural Operations<br>Based on aerial photography review, farming activity occurred in the late 1920s and continued sometime between the 1950s and 1960s on the southern plateau area east of the LADWP easement. Mining activities for aggregate resources also occurred on the same southern plateau during the 1960s. Approximate cuts appear to have been in excess of 30 feet, but less than 50 feet. There are some fill soils remaining from the mining activities in the southern | ensure that construction workers are not exposed to toxic substances.<br><br>G-2 Prior to recordation of the Final Tract Map, initiation of rough grading or issuance of any subsequent permits, the applicant shall prepare a subsequent environmental assessment to document the exact location of the oil well. Re-abandonment of the oil well shall be performed to meet the current requirements of the State of California, Department of Conservation, Division of Oil, Gas & Geothermal Resources (DOGGR). Once re-abandoned, the oil well will not provide a significant impact to the Proposed Project. | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| portion of the southern plateau. Based upon exploration performed by AES, artificial fill up to 14 feet was encountered. No traces of pesticides were identified in the Phase 1 Environmental Site Assessments for the project site. Therefore, impacts would be less than significant.<br><br>*Operation*<br>The Proposed Project is not anticipated to result in an accidental release of hazardous materials into the environment. The proposed YMCA building, the junior high school and the residential dwelling units would utilize limited quantities of common cleaning and maintenance materials, which would be shipped, stored, used and disposed of in accordance with applicable statutes. Based on the amount expected to be stored, nature of packaging, materials involved, and the Proposed Project's required compliance with applicable regulations, the risk from use of these materials is considered to be low and impacts would be less than significant. | | |
| ***Hazardous Materials Sites***<br>The Phase 1 Environmental Site Assessments prepared for the Proposed Project reviewed a database of government-regulated properties having known and/or recognized environmental conditions that have potential environmental concerns in the vicinity of the project. There is a low probability that listed off-site properties in the search vicinity have impacted or are currently impacting the project site. As a result of the low probability of these properties impacting the project site, development of the Proposed Project would result in impacts less than significant. | None required. | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| ***Exposure of People to Potential Health HazardsTransmission Line Exposure***<br>Typical maximum EMF levels at the edge of a 200-foot right-of-way for 230 kV transmission lines would be approximately 1.8-3.6 mG. This level is less than the background levels of 0.5 mG to 4.0 mG, which are typically found in the average home. Because there is no established threshold of significance for exposure to EMFs, there would be no significant impact associated with development of the Proposed Project adjacent to SCE transmission easements. The Proposed Project would not expose people, animal, or plant life populations to known health hazards from SCE transmission lines. No significant impacts from EMFs would occur. | None required. | Less than Significant |
| ***Other Past Usage:***<br>A Phase 1 Site Assessment revealed that a water well was found on the project site, in the area east of the LA DWP easement in the southwestern portion of that area. The presence of the well does not represent a recognized environmental hazardous condition. However, an uncapped or un-abandoned well can serve as a conduit for contaminants to groundwater. The Phase 1 Environmental Site Assessment recommends that the well be plugged and abandoned in accordance with applicable regulatory requirements. With implementation of this mitigation measure, impacts would be less than significant. | G-3 Prior to recordation of the Final Tract Map, initiation of rough grading or issuance of any subsequent permits, the applicant shall prepare a subsequent environmental assessment to document the exact location of the water well. Abandonment of the of the water well shall be performed to meet the current requirements regulatory requirements. | Less than Significant |
| ***Cumulative Impacts:***<br>Development of the 12 related projects, in conjunction with the Proposed Project, would increase the potential for the transport or | None required. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| accidental release of hazardous materials. The one industrial related project, No. 5, is located south of the project site on Soledad Canyon Road. The residential projects are unlikely to use, store, or transport hazardous materials in any material quantities and most likely would be using household cleaning fluids and materials. Hence, there is a very low probability that one or more of the related projects might release hazardous materials into the environment that, in turn, might combine with a release of hazardous materials from the project site to cause cumulative impacts. Therefore, the Proposed Project in combination with the 12 Related Projects would not be expected to result in significant cumulative impacts associated with hazardous materials. | | |
| **HYDROLOGY AND WATER QUALITY** | | |
| ***Water Quality Standards/Waste Discharge***<br>The Proposed Project includes a mix of uses all having the potential to directly and indirectly impact water quality through point and nonpoint sources given their proximity to the Santa Clara River. In addition, short-term construction activities also have the potential to cause a variety of water quality impacts. Therefore, project impacts are considered potentially significant and mitigation is required. | H-1 The Proposed Project shall comply with the RWQCB Municipal Permit (General MS4 Permit) Order No. 01-182, NPDES No. CAS004001 (adopted December 13, 2001) to reduce the discharge of pollutants to the maximum extent practicable.<br><br>H-2 The project applicant shall obtain authorization through the Regional Water Quality Control Board (RWQCB) for a National Pollution Discharge Elimination System (NPDES) permit for general construction activity. The applicant shall avoid and minimize potential temporary water quality impacts by including provisions in the final engineering plans and specifications of each project | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | component together with associated instructions to the contractors, assuring compliance with applicable RWQCB and City of Santa Clarita requirements. The project engineer shall file a notice of intent to discharge stormwater, and an application for the NPDES stormwater permit for general construction activity with the RWQCB before starting construction. All construction activities shall be subject to this requirement.<br><br>H-3 The project's Drainage Concept Study and Hydrologic Analysis shall be reviewed and approved by the Los Angeles County Public Works Department prior to the issuance of any building permits. This analysis shall demonstrate that site drainage can adequately be collected and conveyed via the proposed drainage facilities without significantly impacting downstream hydrology, wetland functions, and/or water quality. | |
| **Groundwater Supplies and Groundwater Recharge**<br>The Proposed Project would not be supplied with water drawn from either regional or local groundwater sources. Thus, the Proposed Project would not substantially deplete groundwater supplies such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level. As a result, impacts to groundwater supplies would be | None required | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| less than significant.<br><br>According to the Basin Plan, the project site is not located directly over a regional groundwater basin. Thus, the Proposed Project would not interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level. As a result, impacts to groundwater recharge would be less than significant. | | |
| ***Alteration of Existing Drainage and Erosion:***<br><br>Two detention basins will be provided on site to offset increases in two year storm flows as a result of project implementation. A reduction in sedimentation and debris production (15,948 cubic yards to 8,401 cubic yards) is a result of reduced erosion of the site due to coverage of much of the development area with pavement, roofs, vegetation, and other non-erosive surfaces. It is also a result of the proposed debris basins that would capture sediment and debris in upstream runoff. With these improvements in place, the project would reduce post-construction impacts on- and off-site erosion, downstream sedimentation, and debris production and transport and, therefore, a less than significant impact. | H-4 The project applicant shall prepare an Erosion and Sediment Control Plan to address construction impacts and long-term operational effects on downstream environments and watersheds. This plan shall be prepared by a qualified Civil Engineer. Proposed management efforts may include (but not be limited to) provisions for the use of vegetative filtering, preparation of detailed erosion control plans, appropriate use of | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | temporary debris basins, silt fences, sediment traps and other erosion control practices. The proposed plan shall also address all relevant NPDES requirements and recommendations for the use of best available technology. The erosion control plan shall be reviewed and approved by the City Engineer prior to issuance of grading permits.<br><br>H-15 By October 1st of each year, a separate erosion control plan for construction activities shall be submitted to the local municipality describing the erosion control measures that will be implemented during the rainy season (October 1 through April 15).<br><br>H-17 Ultimate project hydrology and debris production calculations shall be prepared by a project engineer to verify the requirements for debris basins and/or desilting debris.<br><br>H-18 To reduce debris being discharged from the site, debris basins shall be designed and constructed pursuant to LACDPW Flood Control to intercept flows from undeveloped areas entering into the developed portions of the site. | |
| *Alteration of Existing Drainage and Flooding*<br>The Proposed Project would make alterations to the existing drainage pattern on the project Site by placing fill in canyons and | | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| directing surface runoff into storm drainage facilities. However, all site runoff would continue to flow in approximately the same location as it does currently and would be discharged to the Santa Clara River. Compared to existing site conditions during a 50-year storm, both burned and burned and bulked volumes would be reduced by approximately 14 percent. Therefore, the Proposed Project would not substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or offsite. | H-5 The project applicant shall submit a final drainage report including an evaluation of adequacy of all on-site drainage improvements. The final drainage report shall be based on final project plans and shall provide engineering detail on all proposed drainage improvements demonstrating that such improvements meet all County of Los Angeles requirements and design standards for stormwater infrastructure. The final drainage report shall be submitted to the City of Santa Clarita and County of Los Angeles Public Works Department for review and approval prior to issuance of any project permits. | Less than Significant |
| ***Project Runoff Water and Stormwater Drainage Systems/Additional Sources of Polluted Runoff***<br><br>The Proposed Project would increase the amount of runoff from those areas of the site that would be covered by roads, buildings, paved parking areas, and other relatively impermeable or impervious features. Burned and bulked flows would be reduced as a result of the proposed upstream debris basins that would capture upstream bulk flows and allow debris to settle out from the runoff before it enters the storm system through the developed portion of the site. As a result, there would be a net decrease in runoff and the project would not result in downstream flooding. Since storm flows from upstream areas would be channeled through | H-7 The on-site storm drain (pipes and reinforced concrete boxes) and open channels shall be designed and constructed for either the 25-year of 50-year capital storm.<br><br>H-8 Debris basins shall be constructed pursuant to Los Angeles County Department of Public Works requirements to intercept flows from undeveloped areas entering into the developed portions of the site. | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| the site in facilities designed for the 50-year capital storm, and since on-site runoff would be accommodated in facilities designed for the 25-year Urban Design Storm pursuant to LACDPW requirements, no-site or upstream flooding inadequately designed storm drainage facilities would occur. Also, the inclusion of BMPs in the project design can be expected to prevent substantial additional sources of polluted runoff. Therefore, impacts associated would be less than significant. | H-9 Energy dissipaters consisting of either rip-rap or larger standard impact type energy dissipaters shall be installed as required by LACDPW at outlet locations to reduce velocities of runoff into the channel where necessary to prevent erosion.<br><br>H-10 All on- and off-site flood control improvements necessary to serve the project are to be constructed to the satisfaction of the City of Santa Clarita and/or County of Los Angeles Department of Public Works Flood Control Division. | |
| ***Project Degradation of Water Quality***<br><br>Other than those issues already discussed above, the Proposed Project also has the potential to degrade water quality as a result of onsite sewage generation. The Proposed Project would connect to public sewers and its sewage would be treated by the Santa Clarita Valley Joint Sewerage System. There would be no onsite sewage disposal and the Proposed Project is not expected to otherwise substantially degrade water quality. | H-6 All Best Management Practices (BMPs) proposed in the project's Storm Water Pollution Prevention Plan (SWPPP) shall be implemented prior to and during construction activities. The project contractor shall implement all Best Management Practices as described in the SWPPP to reduce potential water quality impacts. Final review and approval of this plan shall be completed by the City of Santa Clarita prior to issuance of grading permits. At a minimum, the BMPs shall address soil stabilization, sediment control, wind erosion control, tracking control, non-stormwater control, waste management and materials pollution control practices, | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | and emergency spill control and response measures. Typical BMPs that shall be considered for inclusion in the SWPPP include:<br>• temporary sediment control: silt fencing, sandbagging, strawbale ground-covering, fiber roll barriers, and desilting basins;<br>• temporary soil stabilization: hydroseed straw or mulch, seeding, soil binders, erosion control mats or blankets;<br>• preservation of existing vegetation outside construction areas;<br>• construction scheduling outside of the rainy season;<br>• stockpile management: size restriction, runoff control, covers;<br>• sediment tracking control: street sweeping, cover hauling trailers; and<br>• waste management: spill prevention, concrete wash management, material delivery and storage, vehicle fueling and cleaning.<br><br>H-11 Per the April 26, 2001 modification to the General Construction Permit, a contingency "Sampling and Analysis Plan" shall be developed in the event that the BMPs implemented at the construction site fail to prevent non-visible pollutants from discharging from the site. BMPs shall be inspected prior to storm events, every 24 hours during extended events, and after the storm events | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | to ensure proper function of the BMPs and to identify necessary repairs in a timely manner. A record of the inspections and repairs shall be documented in the SWPPP.<br><br>H-12 Following the completion of the construction project and when the site has been stabilized, a Notice of Termination shall be filed with the RWCQB.<br><br>H-13 During all construction phases, temporary erosion control retain soil and sediment on the site shall be implemented, including:<br>• re-vegetating exposed areas as quickly as possible;<br>• minimizing disturbed areas;<br>• diverting runoff from downstream drainages with earth dikes, temporary drains, slope drains, etc.;<br>• velocity reduction through outlet protection, check dams, and slope roughening/terracing;<br>• dust control measures, such as sand fences, watering, etc.;<br>• stabilizing all disturbed areas with blankets, reinforced channel liners, soil cement, fiber matrices, geotextiles, and/or other erosion resistant soil coverings or treatments;<br>• stabilizing the construction entrance/exist with aggregate underdrain with filter cloth or other comparable method;<br>• placing sediment control BMPs at appropriate locations along the site perimeter and all operational internal inlets to the storm drain system at all times during the rainy season (sediment control BMPs may include filtration | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | devices and barriers, such as fiber rolls, silt fence, straw bale barriers, and gravel inlet filters, and/or with setting devices, such as sediment traps or basins; and/or<br>• eliminating or reducing, to the extent feasible, non-storm water discharges (e.g., pipe flushing, and fire hydrant flushing, over-watering during dust control, vehicle and equipment wash down) from the construction site through the use of appropriate sediment control BMPS.<br><br>See also Mitigation Measures H-1 and H-2. | |
| ***Housing Within a 100-year Flood Hazard Area***<br><br>The project encroaches upon the existing FEMA flood hazard area, but the area that encroaches include only open space areas with no proposed housing. | None required. | Less than Significant |
| ***Structures Within a 100-year Flood Hazard Area Impeding or Redirecting Flood Flows***<br><br>The project encroaches upon the existing FEMA flood hazard area, but the area that encroaches include only open space areas with no proposed housing. | None required. | Less than Significant |
| ***Exposure of People or Structures to a Significant Risk of Loss, Injury or Death Involving Flooding*** | | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| The project site is located inland from the Pacific Ocean and not in proximity to any large, continuously filled bodies of surface water; therefore, it is not subject to seiche or tsunamis. The site is subject to some debris flows; however, adequate building setbacks from natural slopes and debris control facilities proposed in upstream areas of the site would protect the project development from mudflow hazard. Therefore, project impacts relating to exposure of people or structures to a significant risk of loss, injury, or death involving flooding would be less than significant. | None required. | Less than Significant |
| ***Exposure of People or Structures to a Risk of Levee or Dam Failure***<br><br>As discussed above, the project site is not in the potential inundation area of an upstream levee or dam. Therefore, the Proposed Project would not expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam. | H-14 All necessary permits, agreements, letters of exemption or a Verification Request Letter from the Army Corps of Engineers and/or the California Department of Fish and Game for Project related development are to be obtained prior to issuance of grading permits.<br><br>H-16 A final developed condition hydrology analysis shall be prepared in conjunction with final project design when precise engineering occurs. This final analysis will be done to confirm that the final project design is consistent with the analysis. Those final calculations shall establish design features for the project that satisfy the criterion that post development peak storm water runoff discharge rates, velocities, and duration in natural drainage systems mimic | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | pre-development conditions. All elements of the storm drain system shall conform to the policies and standards of the Los Angeles County Department of Public Works, Flood Control Division, as applicable. | |
| ***Cumulative Impacts:***<br><br>The Proposed Project and any future projects in the Santa Clara River watershed must include project PDFs (site design, source control, and treatment control BMPs) in compliance with the requirements of the Los Angeles County NPDES Permit (Order No. 01-182) and the Los Angeles County SUSMP. In addition, the Proposed Project, as well as any future projects in the watershed must comply with the Construction General Permit and General Waste Discharge Requirements. Each of these regulatory requirements is intended to be protective of water quality and beneficial uses in the project receiving waters. Therefore, compliance of the Project with the MS4 Permit, the LA County SUSMP, and the Construction General Permit and General Waste Discharge Requirements constitutes compliance with regulatory requirements that address cumulative water quality impacts and to assure mitigation of those impacts to a less-than-significant level. | None required. | Less than Significant |
| **LAND USE** | | |
| ***Community Division:***<br>The project site is currently undeveloped and bounded to the north by a residential development currently under construction and to | None required. | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| the northwest by an existing residential neighborhood. The City has recently approved a residential and commercial development project to the west. Further, the land to the east is currently developed with single-family homes. Therefore, the Proposed Project would not physically divide any established community or uses and impacts would be less than significant. | | |
| ***Conflict with any Applicable Conservation Plan or Natural Community Conservation Plan:***<br>The project site boundary includes portions of the Santa Clara River (Lot 123) which is designated as a Significant Ecological Area (SEA)(No. 23). The project applicant does not proposed development within the SEA. Further, there are no habitat conservation plans or natural community conservation plans that are applicable to the Proposed Project. Therefore, the Proposed Project would not conflict with any habitat conservation plan or community conservation plan and impacts would be less than significant. | None required. | Less than Significant |
| ***Consistency with Land Use Plans:***<br>*City of Santa Clarita – General Plan*<br>The proposed Keystone project may be consistent with the RS, RMH and IC development standards pertaining to these land use designations subject to approval of the General Plan Amendment (GPA) by City Council | None required | Less than Significant |
| *Consistency with City of Santa Clarita General Plan Element Goals and Polices* | None required. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| The City of Santa Clarita General Plan contains goals and numerous policies to guide development and uses planned within the City. Existence of an inconsistency between a Proposed Project and an applicable general plan is a legal determination, vested in the City Council and subject to court review if challenged. Inconsistency is not an impact under CEQA – plan inconsistencies in and of themselves are not significant impacts on the environment under CEQA. The City of Santa Clarita General Plan Element Goals and Policies and their applicability to the Proposed Project are discussed in Table V.I-4, which is found in Section V.I, Land Use. | | |
| *Consistency with the Unified Development Code*<br><br>The proposed Keystone project may be consistent with the RS and RMH zones that correspond to the City's General Plan land use designations and the proposed uses are permitted under these districts subject to approval of the Zone Change by City Council. The project would be subject to the general requirements for development and grading under the UDC. | None required. | Less than Significant |
| ***Cumulative Impacts:***<br><br>Cumulative land use impacts could occur if other related projects in the vicinity of the project site would result in land use impacts in conjunction with the Proposed Project. Twelve proposed or approved projects were identified that could potentially contribute to the cumulative effects of the Proposed Project (see Figure III-X | None required. | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| in Section III (Related Projects)). Development of the Proposed Project in conjunction with the related projects would result in an intensification of existing prevailing land uses in the project vicinity.<br><br>The Proposed Project would not physically divide an established community and subject to approval by City Council of the GPA and Zone Change would conflict with any applicable land use plan, regulation, habitat conservation plan or natural community conservation plan. Therefore, the Proposed Project's incremental increase is not considerable and impacts are less than significant. | | |
| MINERAL RESOURCES | | |
| ***Loss of Availability of a Known Mineral Resource that would be of Value to the Region:***<br>A small portion of the project site adjacent to the southern site margin is contained within a Mineral Resources Zone-2 (MRZ-2) classification, which includes a project designated approximately 15-acre open space lot and a 0.55-acre industrial lot. Neither lot is proposed for development. Given that no development is proposed within the project site land classified as MRZ-2, implementation of the project would not preclude or impede mineral resource extraction from MRZ-2 classified land. Thus, there would be no impact to the availability of known mineral resources.<br>Conversion of the majority of the project site to urban uses would not result in a loss of availability of a known mineral resource that would be of value to the region and the residents of the state. | None required. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| Thus, impacts would be less than significant. | | |
| ***Impacts Related to the Loss of Availability of a Locally-Important Mineral Resource Recovery Site Delineated on a Local General Plan, Specific Plan, or Other Land Use Plan:*** Though a small portion of the site (approximately 15.5-acres) is within a mineral resource classification of MRZ-2, the City's General Plan does not envision the site suitable as conservation for resource recovery. Therefore, project implementation would not result in the loss of a locally-important mineral resource recovery site delineated on a local general plan, specific plan or other land use plan; thus, no impact would occur. | None required. | Less than Significant |
| ***Cumulative Impacts:*** Cumulative mineral resource impacts could occur if other related projects in the vicinity of the project site in conjunction with the Proposed Project would result in the loss of recoverable mineral resources. Twelve proposed or approved projects were identified that could potentially contribute to the cumulative effects of the Proposed Project within a two mile radius of the project site. Related Project Nos. 3, 4, 5 and 6 are within MRZ-3 mineral resource category and border MRZ-2. Related Project Nos. 1, 7, 8, 9 and 10 are within MRZ-3 while Related Projects Nos. 11 and 12 are also within MRZ-3 but border MRZ-1. Development of the Proposed Project in conjunction with the related projects would result in urbanization of existing undeveloped land in the project vicinity. | None required. | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| The Proposed Project and related projects have proposed development on land classified as MRZ-3. The closest related project that has land on the Santa Clara River (which is classified as MRZ-2) is Related Project No. 4, Riverpark. Like the Proposed Project, Riverpark does not propose development within the Santa Clara River which is an SEA. Though mineral and aggregate resource extraction could occur, it would not be likely as the Santa Clara River in the project site vicinity does not have a MOCA overlay which would permit such activity. Therefore, no development would occur in MRZ-2 and impacts would not be cumulatively considerable. | | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| NOISE | | |
| ***Construction-Related Noise:*** Project development would require the use of heavy equipment for ground clearing, site grading, roadway construction, and building construction. Construction activities would primarily affect the existing residences located immediately east and west of the Proposed Project site. Assuming that average daytime noise levels average around 45 dBA $L_{eq}$ at these homes (based on the noise levels monitored at the project site), noise levels associated with project implementation would represent a substantial periodic increase in ambient noise levels in the project vicinity above levels existing without the project. These daytime noise levels would exceed City standards for residential uses and would continue to constitute a substantial increase in ambient noise levels in the project vicinity above levels existing without the project. This is a significant noise impact. | K-1 The Applicant should implement measures to reduce the noise levels generated by construction equipment operating at the project site during project grading and construction phases. The Applicant should include in construction contracts the following requirements or measures shown to be equally effective:<br>• All construction equipment shall be equipped with improved noise muffling, and have the manufacturers' recommended noise abatement measures, such as mufflers, engine covers, and engine isolators in good working condition.<br>• Stationary construction equipment that generates noise levels in excess of 65 dBA $L_{eq}$ shall be located as far away from existing residential areas as possible. If required to minimize potential noise conflicts, the equipment shall be shielded from noise sensitive receptors by using temporary walls, sound curtains, or other similar devices.<br>• Heavy-duty vehicle storage and start-up areas shall be located a minimum of 150 feet from occupied residences where feasible.<br>• All equipment shall be turned off if not in use for more than five minutes.<br>• An information sign shall be posted at the entrance to each construction site that identifies the permitted construction hours and provides a | Significant and Unavoidable |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | telephone number to call and receive information about the construction project or to report complaints regarding excessive noise levels. | |
| ***Construction-Related Groundborne Vibration:*** Groundborne vibrations levels would not approach the 80 VdB threshold at residences near the project site. This would be a less-than-significant impact regarding the exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels. | None required. | Less than Significant |
| ***Operational Noise Levels - On-site:*** Future exterior noise levels at most of the proposed land use locations, as well as interior noise levels throughout the project area would not exceed City standards. However, the future exterior noise levels at several of the buildings proposed along Golden valley Road could exceed City standards. Heating, ventilation, and air conditioning (HVAC) systems would be installed for the new buildings within the Proposed Project site. Residential HVAC systems result in noise levels that average between 40 and 50 dBA $L_{eq}$ at 50 feet from the equipment. These noise levels would not exceed the City's exterior noise standards. Future residents of the project site could be exposed to exterior noise levels that exceed City standards. This would be a potentially significant noise impact. | K-2 Lot 97: Prior to the issuance of building permits for the multi family units of Lot 97 located along Golden valley Road (only those units that front Golden valley Road), the project developer shall submit environmental noise analyses that demonstrate that future exterior noise levels at ground floor porches and upper floor balconies will not exceed 65 dBA CNEL. Buildings that could be exposed to future exterior noise levels above 65 dBA CNEL shall either (1) have increased setbacks from Golden Valley Road (estimated to be approximately 145 feet from the centerline of Golden Valley Road) or (2) barriers shall be designed and constructed between the buildings and roadway (estimated to have a height of one foot above the roadway grade). The barriers could be in the form of earthen berms or solid masonry walls.<br>K-2 Lot 97: Prior to the issuance of building permits for the multi family units of Lot 97 located along Golden Valley | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | Road (only those units that front Golden Valley Road), the project developer shall submit environmental noise analyses that demonstrate that future exterior noise levels at ground floor porches and upper floor balconies will not exceed 65 dBA CNEL. Buildings that could be exposed to future exterior noise levels above 65 dBA CNEL shall either (1) have increased setbacks of the exterior porches or balconies from Golden Valley Road (estimated to be approximately 145 feet from the centerline of Golden Valley Road) or (2) barriers shall be designed and constructed between the buildings and roadway (estimated to have a height of one foot above the roadway grade). The barriers could be in the form of earthen berms or solid masonry walls.<br>K-3 Lot 98: Prior to the issuance of building permits for the multi family units of Lot 98 located along Golden Valley Road (only those units that front Golden Valley Road), the project developer shall submit environmental noise analyses that demonstrate that future exterior noise levels at ground floor porches and upper floor balconies will not exceed 65 dBA CNEL. Buildings that could be exposed to future exterior noise levels above 65 dBA CNEL shall either (1) have increased setbacks of the exterior porches or balconies from Golden Valley Road (estimated to be approximately 145 feet from the centerline of Golden Valley Road); (2) have barriers designed and constructed around the balconies; or (3) not provide balconies that face Golden Valley Road in the affected residential units. The | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | barriers could be in the form of 3/8inch glass or 5/8-inch plexiglass to a height of six feet above the floor elevation. It is not expected that earthen berms or solid masonry wall built to a standard height of six feet along the edge of the property could reduce noise levels at the second and third floor balconies.<br>K-4 Lot 100: Prior to the issuance of building permits for the multi family units of Lot 100 located along Golden Valley Road (only those units that front Golden Valley Road), the project developer shall submit environmental noise analyses that demonstrate that future exterior noise levels at ground floor porches and upper floor balconies will not exceed 65 dBA CNEL. Buildings that could be exposed to future exterior noise levels above 65 dBA CNEL shall either (1) have increased setbacks of the exterior porches or balconies from Golden Valley Road (estimated to be approximately 150 feet from the centerline of Golden Valley Road); (2) have barriers designed and constructed around the balconies; or (3) not provide balconies that face Golden Valley Road in the affected residential units. The barriers could be in the form of 3/8inch glass or 5/8-inch plexiglass to a height of six feet above the floor elevation. It is not expected that earthen berms or solid masonry wall built to a standard height of six feet along the edge of the property could reduce noise levels at the second and third floor balconies. | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| ***Operational Noise Levels –Locations Off Site:*** Locations in the vicinity of the Proposed Project site could experience slight changes in noise levels as a result of an increase in the on-site population and resulting increase in motor vehicle trips. The Proposed Project would increase local noise levels by a maximum of 0.2 dBA CNEL, which is inaudible/imperceptible to most people and would not exceed the identified thresholds of significance. | None required. | Less than Significant |
| ***Operational Groundborne Vibration:*** When the Proposed Project is completed and operational, background vibration levels would be expected to average around 50 VdB, which is substantially less than the 80 VdB threshold for residential buildings. Impacts would be less than significant. | None required. | Less than Significant |
| ***Cumulative Impacts:*** With the proposed extension of Ermine Street to Golden Valley Road, residents of the residential area east of the Proposed Project site are expected to use Ermine street as an alternate route for traveling to the western area of Santa Clarita. The combined noise levels of Ermine Street and Golden Valley Road would result in average noise levels of approximately 54.0 dBA CNEL at the homes located at the western end of Ermine Street. Approximately 52.3 dBA CNEL is associated with the increased traffic along Ermine Street. Although the resulting noise levels at these homes would be well below the City's 65.0 dBA CNEL standard for residential uses, the existing noise levels in this area is estimated to be approximately 45.0 dBA CNEL. The increase of approximately | | Cumulatively considerable. |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| 9.0 dBA CNEL above the existing noise level at this location would be considered substantial and, therefore, a significant cumulative impact. Although few of the residents of the Proposed Project are expected to use this roadway to travel east of the project site, the roadway extension would not occur without the Proposed Project. Therefore, the contribution of the Proposed Project to the cumulative impact would be considerable. | | |
| POPULATION AND HOUSING | | |
| ***Population and Housing:*** As the project site is currently undeveloped, the increase in residential population represents a 100% population and housing increase on the project site. This population growth and the addition of dwelling units to the City's housing inventory are not anticipated to be substantial compared to citywide growth projections. The increase in population is considered minimal, as it would represent 1.6% of the City's projected 2010 (the year closest to project build-out) population of 187,795, and 7.9% of the City's in-migration for the period between 2000 and 2010 (32,707 new residents). The Proposed Project would add 96 single-family and 883 multi-family residences to the City's housing inventory. This increase represents 1.6% of projected housing units within the City for 2010 (61,101 units) and 9.6% of the new housing units projected to be added for the period between 2000 and 2010 (10,214 new units). Further, the addition of 979 dwelling units to the City's housing inventory would not exceed the projected growth rates for the City. Impacts relating to population and housing | None required. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| would be less than significant. | | |
| ***Employment:***<br>*Construction Impacts*<br>Construction of the Proposed Project would result in increased employment opportunities during the project's construction period. However, construction workers would likely be drawn from the construction employment labor force already resident in the surrounding communities and it is not likely that construction workers would relocate their place of residence as a consequence of working on the Proposed Project.<br><br>*Long-Term Operation Impacts*<br>The Junior High School is expected to have an enrollment of approximately 1,200 students and would be expected to generate 132 net new jobs (though the Hart District anticipates approximately 70 faculty). The YMCA Community / Fitness Center will be housed in an approximately 30,476 square foot facility and would be expected to generate 72 net new jobs. Thus the Proposed Project would generate a total of 204 new jobs. This increase represents 0.36% of projected jobs with in the City for 2010 (57,248 jobs) and 2.67% of the new jobs projected to be added for the period between 2000 and 2010 (7,636 new jobs). Because the Proposed Project would represent only a 0.36% increase in employment opportunities within the City, this increase is not considered to be substantial in terms of employment growth. | None required. | Less than Significant |
| ***Indirect Growth:*** | | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| The proposed roadways and other infrastructure associated with the project would not induce growth because they would only serve project residents and would not extend into previously undeveloped areas that would then be made available for future development. As a result, development of the Proposed Project would not indirectly induce substantial population growth and impacts relating to population and housing would be less than significant. | None required. | Less than Significant |
| ***Housing or Population Displacement:***<br>The Proposed Project site is currently undeveloped and does not contain any housing or people. Therefore, implementation of the Proposed Project would not displace substantial numbers of existing housing or substantial numbers of people necessitating the construction of replacement housing or replacement of affordable housing. No significant impacts would occur. | None required. | Less than Significant |
| ***Cumulative Impacts:***<br>The dwelling units that would be developed with implementation of the Proposed Project in combination with the related projects would concurrently increase the resident population in the area. The 5,273 dwelling units that would be developed with the related projects in combination with the Proposed Project's 979 dwelling units would yield a total of approximately 19,106 new residents. The total number of employees generated by the Proposed Project and related projects would be approximately 878. The residential population would increase by approximately 2,683 people and 878 households. This would result in a cumulative population increase | None required. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| of 21,789 people. The addition of 21,789 new people would be within the City of Santa Clarita's forecasted increase of 36,707 people between 2000 and 2010. The Proposed Project in combination with the related projects would not result in a significant impact on population or housing because the number of people and homes that would be generated by the Proposed Project in combination with the related projects is within current Santa Clarita Valley population and housing forecasts; roadways and other infrastructure are not anticipated to be extended into previously undeveloped areas that would be available for future development; and the Proposed Project would not result in or contribute to the displacement of housing or people. Therefore, cumulative impacts on population and housing would be less than significant. Thus, the project's incremental increase is not considerable and impacts would be less than significant. | | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| **PUBLIC SERVICES** | | |
| ***Police Protection:***<br>*Short-Term Construction Impacts*<br>During the construction phase, additional LASD's services would be required in the project area, as the project site would increase the number of people on-site from existing demand. This increase in daytime population would vary depending on the type of construction activity (i.e. site grading, construction of structures, infrastructure improvements, etc.). Therefore, during the construction phase, private security patrols would be utilized to protect the project site; thereby, reducing potential demands on the existing LASD's resources. In addition, temporary fencing would also be installed around the construction site to keep out the curious. With implementation of the mitigation measures, no significant short-term construction impacts are anticipated.<br><br>*Long-term Operational Related Impacts*<br>Assuming a residential density of 3.056 persons per dwelling unit, the Proposed Project would generate a population increase of 2.992 persons. Recreational uses would provide a trail system linking to the Santa Clara River Trail and a YMCA facility and a proposed junior high school would provide additional educational facilities for the existing and proposed residential development. Consequently, an increase in the number of requests for assistance calls for the police services from new homes would be expected. The LASD's resources are already strained by a chronic shortage of uniformed officers, a situation that may not improve in the | M.1-1 During construction, private security patrols shall be utilized to protect the project site and temporary fencing would also be installed around the construction site to keep out the curious.<br><br>M.1-2 As final building plans are submitted to the City for approval in the future, Sheriff's Department design requirements which reduce demands for service and ensure adequate public safety (such as those pertaining to site access, site security lighting), shall be incorporated into building designs.<br><br>M.1-3 Project design shall provide lighting, to the satisfaction of the Sheriff's Department, around and throughout the development to enhance crime prevention and enforcement efforts.<br><br>M.1-4 Project design shall provide clearly visible (during the day and night) address signs and/or building numbers for easy identification during emergencies.<br><br>M.1-5 Project design shall provide visibility of doors and windows from the street and between buildings.<br><br>M.1-6 Project site design shall include adequate parking spaces in the parking lots to accommodate residents, | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| foreseeable future.<br><br>The Proposed Project would include significant crime prevention design features and as the project is developed, tax revenues from property and sales taxes would be generated and deposited in the City of Santa Clarita General Fund. A portion of these revenues would then be allocated, in accordance with the City of Santa Clarita and County of Los Angeles contractual service agreement, to maintain staffing and equipment levels for the Santa Clarita Valley Sheriff's Substation in response to related demands. Although the project would increase demands for Sheriff's services, these service demands can be met through the allocation of revenues collected from the project using existing sources. Though the Proposed Project could increase staffing levels at the Sheriff's substation, the increase in staff and equipment would not result in the need to physically alter the physical plant (Santa Clarita Sheriff's Substation), construction of which could cause significant environmental impacts in order to maintain service ratios and response time. Consequently, impacts on the Santa Clarita Valley Sheriff's Substation would be less than significant. | per the Unified Development Code. | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| *City Emergency Response/Evacuation Plans:*<br>The primary vehicle access to the project site would be via a major arterial, Golden Valley Road, which would run north-south axis through the site. The roadway will be eventually constructed with a flyover Soledad Canyon Road to connect with Newhall Ranch Road. The project would also include approximately 19 acres of other public streets, including the access roadway to the multi-family lots and the access roadway to the single-family neighborhood including cul-de-sacs. These roadways would provide alternative evacuation routes for the site, thus it is not anticipated that the design of the project would preclude implementation of an evacuation plan, which would provide for the safe movement of future residents. Consequently, no significant impacts are expected to occur. | None required | Less than Significant |
| *Fire Protection:*<br>*Short-Term Construction Impacts*<br>Construction of the Proposed Project would increase the potential for accidental wildfires from such sources as the operation of mechanical equipment in close proximity to fire-prone vegetation, use of flammable construction materials, and from carelessly discarded cigarettes. In most cases, the implementation of "good housekeeping" procedures by the construction contractors and the work crews would minimize these hazards. Nonetheless, as the Proposed Project's construction-related activities would increase the potential for starting a wildfire, and since LACFD has determined that the development of the Proposed Project would require additional manpower, equipment and facilities, without | M.2-1 The project developer shall contribute funds to the Los Angeles County Fire Department Developer Fee Program. The exact contribution shall be determined by the Los Angeles County Fire Department before a building permit is issued.<br><br>M.2-2 The project shall prepare a Fuel Modification Plan, landscape plan and irrigation plan as required for projects located with a Very High Fire Hazard Severity Zone. The Fuel Modification Plan shall be submitted and approved by the County Fire Department prior to final map recordation. The Fuel Modification Plan shall depict a fuel modification | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| proper mitigation measures a potentially significant impact would occur.<br><br>*Long-term Operational Related Impacts*<br><br>The intensification of land uses combined with the increase in human activity on the project site and due to the location of the project site in an area designated as VHFHSZ would result in an increase in fire hazards and other associated needs for fire protection services.<br><br>As such, the Proposed Project would meet all applicable County and City fire codes, including those related to commercial, institutional, and residential uses per the LACFD with respect to street width, turning radius and access for emergency vehicles and location and number of fire hydrants. Specifically, the Proposed Project would implement a fuel modification plan.<br><br>The Fire Department has stated that no fire station is required for development mitigation for this specific project. Nonetheless, based on a preliminary review of the Proposed Project, the LACFD has determined that additional manpower, equipment, and facilities would be needed to serve the Proposed Project in order to maintain adequate staffing and response times. Therefore, without appropriate mitigation measures a potentially significant impact would occur. | zone in conformance with the Fuel Modification Ordinance in effect at the time of subdivision. The fuel modification plan shall not conflict with any revegetation plans as discussed in Section V.D (Biological Resources).<br><br>M.2-3 The project shall provide water mains, fire hydrants and fire flows as required by the County of Los Angeles Fire Code.<br><br>M.2-4 Fire Department access shall be extended to within 150 feet distance of any exterior portion of all structures.<br><br>M.2-5 Access shall comply with Section 902 of the Fire Code, which requires all weather access. All weather access may require paving.<br><br>M.2-6 Access roads shall be maintained with a minimum of ten feet of brush clearance on each side. Fire access roads shall have an unobstructed vertical clearance clear-to-sky.<br><br>M.2-7 All fire lanes must not be less than 26 feet paved width (clear to sky and unobstructed) and posted and red curbed "NO PARKING - FIRE LANE". Any proposed reduction in fire lane shall be subject to written acceptance by the County Fire Department. | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | M.2-8 All private gates shall comply with Regulation 5 of the Fire Code. Prior to the approval of the Tentative Tract Map, the applicant shall receive approval of the gates from the Los Angeles County Fire Department. | |
| ***Schools:***<br>The development of the Proposed Project would bring new students into the Saugus Unified School District (SUSD) and the William S. Hart School District (HUSD), as 979 new dwelling units would be built. As such, 334 additional students associated with the Proposed Project would be generated as a result of project implementation. The schools in the SUSD, which would serve the project site are currently operating under capacity and could accept additional students generated by the Proposed Project without exceeding capacity. Consequently, the project would not require additional facilities, such as additional classrooms, to accommodate its students. Therefore, implementation of the project would not result in adverse physical impacts associated with the provision of new or physically altered school facilities, the construction of which could cause significant environmental impacts. No project impacts to the SUSD would occur.<br><br>The junior and high school students, which could possibly be introduced to the HUSD by the Proposed Project would attend schools which are currently over capacity. The School Funding Agreement between the applicant and HUSD would provide a 'Fair Share' mitigation fee to the HUSD that would ensure adequate | M.3-1 Compliance with the provisions of SB 50 is deemed to be complete and adequate mitigation of Proposed Project impacts to school facilities. In addition, project participation in School Facilities Funding Agreements with the SUSD and HUSD would further mitigate project specific impacts on these districts. These agreements would provide for a 'Fair Share' fee to be paid to the SUSD and the HUSD in order to house the additional students generated by the project. No further mitigation is required. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| school capacity to serve this project. In addition, the Proposed Project proposes to sell a portion of the project site to HUSD for the construction of a junior high school. As a result, no project impacts to the William S. Hart School District would occur. The potential environmental impacts of construction of a junior high school on the Proposed Project's school site are analyzed in this environmental impact report. | | |
| ***Libraries:*** The Proposed Project would increase the local permanent residential population by 2,992. Using the County Library's planning guidelines of 0.50 square feet of library facilities and 2.75 collection items per capita, the Proposed Project would generate a need for an additional 1,496 square feet of library facilities and 8,228 additional collection items. As discussed above, the Santa Clarita Valley is currently under-served with regard to Library services and development of the Proposed Project would thereby increase the existing need for additional library facilities. If the project generated demand for 1,496 square feet of additional space were translated into new construction of permanent space, this would be the approximate equivalent of three rooms measuring 20' x 20'. The construction of new, permanent space could be considered an adverse impact under the CEQA Guideline threshold. However, CEQA Guidelines, Section 15301, states that construction on an existing use that totals either 2,500 square feet or 50 percent of the floor area of the structure before the addition would have a negligible impact on the environment. Therefore, the additional construction of approximately 1,496 square feet on the | None required. | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| Jo Anne Darcy Library would have a physically insignificant effect on the environment. For these reasons, the project's impacts on County Library facilities would be less than significant.<br><br>Based on the current library mitigation fee of $677.00 per dwelling unit, the Proposed Project would be required to pay a fee of $662,783.00 ($677.00 x 979 dwelling units = $662,783.00) toward the construction of expanded or new library facilities and the acquisition of additional collection materials. Payment of the library mitigation fee is a requirement of the project by Los Angeles County and the City of Santa Clarita to offset the demand recreated by the project for additional square footage and library collection materials. Impacts would be less than significant. | | |
| ***Parks:*** Future residents of the project site would increase the demand for recreational facilities and opportunities in the project area. The Keystone project includes active recreational facilities for public use, including ball fields and courts located at the junior high, and trails and open space uses. In addition, each multi-family community would contain active recreation area including swimming pools, children's play areas, etc. However, the project is required to pay Quimby fees that would satisfy the need for any new or physically altered parks or recreational facilities in order to maintain current service ratios. Therefore, project impacts on parks and recreational facilities would be less than significant. | M.5-1 Developer shall construct all trails (within the Proposed Project site and off-site to the west) and shall be in accordance with the City of Santa Clarita Department of Parks, Recreation and Community Services trail system standards. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| ***Cumulative Impacts:***<br>Police Protection<br>The Sheriff's substation serving the City of Santa Clarita operates at an adequate level of service. This service is expected to be maintained as cumulative development projects would contribute to the City of Santa Clarita's General fund through taxes and fees which in turn would provide funds to mitigate any cumulative impacts to Sheriff's services to a level of non-significance as long as the City of Santa Clarita and the County of Los Angeles maintain service and funding agreements. Therefore, the Proposed Project and related projects impacts cumulatively would not be considerable and impacts to Sheriff's services would not be significant. | None required. | Less than Significant |
| Fire Protection<br>The project and related projects cumulatively could result in an increase in the average response time for fire protection. However, project specific mitigation measures are required and therefore the impacts resulting from new development would be reduced to less-than-significant by compliance with state, City, and County fire codes, standards and guidelines and the incorporation of project-specific mitigation measures. Moreover, developer fees as determined by the Los Angeles County Fire Department and increased taxes paid by new development would provide revenues to increase staff and purchase new equipment. Therefore, | None required | Less than significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| cumulative project and related project impacts on fire protection services would not be cumulatively considerable and impacts would be less-than-significant. | | |
| Schools<br>Cumulative development would generate 1,853 elementary school students, 656 junior high school students and 992 senior high school students that would need to be accommodated by the SUSD and the HUSD, respectively. Capacity for these students has yet to be fully planned in the subject school districts and unless these additional students can be accommodated, build-out under this scenario could result in a significant impact to schools and educational services. However, compliance as appropriate, with existing School Facilities Funding Agreements and/or other funding mechanisms (e.g., SB 50, the Valley-Wide Joint Fee Resolution, and/or new school facilities funding agreements) would reduce cumulative development impacts on the school districts and project and related project impacts would not be cumulatively considerable and impacts would be less-than-significant level. | None required | Less than Significant |
| Library<br>Payment of the library mitigation fee is a requirement of the project by Los Angeles County and the City of Santa Clarita to offset the | None required | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| demand recreated by the project for additional square footage and library collection materials. Therefore, funding would be provided to offset these demands and provide the County Library system the ability to provide library services and facilities. For these reasons, the project and related project cumulative impacts on to the County Library system under the DMS scenario would not be cumulatively considerable and impacts would be less than significant. | | |
| Parks<br>In accordance with CEQA Guidelines Section 13130(a)(3), the Proposed Project's contribution to the cumulative impacts on parks and recreational facilities would not be cumulatively considerable because the project developer would (1) provide onsite recreational facilities and preserved open space and (2) to the extent that such facilities and open space are insufficient to satisfy fully the project developer's Quimby Act obligations, pay Quimby fees. The satisfaction of the Quimby Act requirements would constitute the project's fair share of mitigation designed to alleviate the cumulative impact on parks and recreational facilities. Therefore, cumulative impacts of the Proposed Project in combination with the related projects would not be cumulatively considerable and impacts would be less than significant. | None required | Less than Significant |
| **UTILITIES AND SERVICE SYSTEMS** | | |
| *Water:*<br>Water Supply Assessment | | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| The Water Supply Assessment for the Proposed Project concluded that "there will be sufficient water supply available when The Keystone project is ready for occupancy, in addition to existing and other planned future uses." Therefore, it is anticipated that the future water supplies will meet the demand of the Proposed Project in addition to the existing demand and the associated impact would be less than significant. Nonetheless, mitigation measures are recommended to further reduce the Proposed Project's less-than-significant impact on water supplies and to support the water conservation efforts of the CLWA.<br><br>Water Facilities<br>The number of water connections that would be added to the existing water supply system in the Santa Clarita Valley is within the growth projections in the 2000 UWMP, as amended. As discussed in the Water Supply Assessment for the Proposed Project, the 2000 UWMP assumed an average growth rate of 2,240 connections per year based on the average growth rate that occurred during the 1990s. The Proposed Project would add approximately 331 residential connections, which is less than the annual average anticipated by the 2000 UWMP and is, therefore, considered to be accounted for in the 2000 UWMP, as amended. | N.1-1 The project developer shall ensure that the landscape irrigation system be designed, installed and tested to provide uniform irrigation coverage. Sprinkler head patterns shall be adjusted to minimize over spray onto walkways and streets.<br><br>N.1-2 The project developer shall install either a "smart sprinkler" system to provide irrigation for the landscaped areas or, at a minimum, set automatic irrigation timers to water landscaping during early morning or late evening hours to reduce water losses from evaporation. Irrigation run times for all zones shall be adjusted seasonally, reducing water times and frequency in the cooler months (fall, winter, spring). Sprinkler timer run times shall be adjusted to avoid water runoff, especially when irrigating sloped property.<br><br>N.1-3 The project developer shall select and use drought-tolerant, low-water consuming plant varieties to reduce irrigation water consumption.<br><br>N.1-4 The project developer shall install ultra-low flush water toilets and water-saving showerheads in new construction. Low-flow faucet aerators should be installed on all sink faucets. | Less than Significant |
| *Sewer:* | N.2-1 Applicant shall obtain a will-serve letter from the County | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| The amount of construction-related wastewater that would be generated would not have a significant impact on local disposal or treatment facilities due to the expected low volume of waste.<br><br>Upon completion, the Proposed Project would generate approximately 235,431 gallons of sewage per day. The existing Soledad Canyon trunk line in the project vicinity has a design capacity of 3.9 mgd and currently conveys a peak flow of 2.4 mgd, leaving 1.5 mgd of remaining capacity. Since the Proposed Project would be anticipated to generate 0.24 mgd, the trunk sewer is considered adequate to accommodate flow projections. It is therefore concluded that the project would not have a significant adverse impact on the District's trunk sewer. | Sanitation Districts of Los Angeles County prior to issuance of building permits in order to verify that there is sufficient capacity in the receiving trunk lines and the reclamation plant to serve the project.<br><br>N.2-2 All local wastewater lines within the project boundaries are to be constructed by the applicant and dedicated to the City of Santa Clarita Transportation and Engineering Services Department.<br><br>N.2-3 Prior to the issuance of building permits, the applicant shall pay wastewater connection fees. | |
| *Solid Waste:*<br>*Short Term Construction Impacts*<br>Construction of the Proposed Project would be expected to generate approximately 7,668 tons of waste over project build-out. Recycling of construction-related waste materials in compliance with AB 939, assuming a 50% diversion rate, means that approximately 3,438 tons of solid waste over project build-out would go to landfills. The total landfill capacity in Los Angeles County is limited, therefore any addition to the overall waste stream flowing to the County's landfills will hasten the day the County eventually runs out of landfill capacity. Therefore and any additional solid waste from any source may be considered adverse. | *Mitigation Measures Already Incorporated Into the Project*<br>N.3-1 Solid waste collection/recycling areas are to be compatible with nearby structures, secure, protected against adverse environmental conditions, clearly marked, adequate in capacity, number and distribution, and contain a sufficient number of bins to serve the recycling and solid waste needs of the development. (Model Ordinance)<br><br>N.3-2 Design and construct collection/recycling areas to accommodate front-loader packing trucks, including | Significant and Unavoidable |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| However, since the addition of the Proposed Project's construction related wastes to the local landfills (i.e. the Chiquita Canyon Landfill, the Antelope Valley Public Landfill I and II and The Lancaster Landfill and Recycling Center), estimated to be approximately 4.4 tons per work day[3], would not cause those landfills to exceed their permitted daily capacity of an aggregate 9,500 tons per day, this impact would be considered less than significant. Because an adequate amount of landfill space has not been ensured to accommodate long-term solid waste disposal at current generation rates, even with mitigation, the Proposed Project's construction-related solid waste impact would be considered significant. | maneuvering room. (Model Ordinance)<br><br>N.3-3 Design and construct driveways and/or travel aisles with adequate width and maneuverability space of unobstructed garbage collection, trash container storage and vehicle access and clearance. (Model Ordinance)<br><br>N.3-4 Post signs at all access points of the recycling areas that clearly identify all recycling and solid waste collection and loading areas and the materials accepted therein. (Model Ordinance)<br><br>N.3-5 The applicant shall comply with all applicable state and Los Angeles County regulating and procedure for the use, collection and disposal of solid and hazardous wastes.<br><br>*Project Mitigation Measures*<br><br>Short-term Construction<br>N.3-6 The construction contractor shall only contract for waste disposal services with a company that recycles construction related wastes. | |

[3] 3,438 tons of solid waste over project build-out / 780 work days (approximately three years) = 4.4 tons per work day.

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| | N.3-7 To facilitate the on-site separation and recycling of construction related wastes, the construction contractor shall provide temporary waste separation bins, which shall be prominently placed on each construction site.<br><br>N.3-8 All construction documents shall specify that building materials shall be made of recycled materials, or materials with the highest content possible of recycled materials, to the extent feasible. | |
| *Long-term Operational Impacts*<br>Over the long term the project's 979 residences, Junior High School and YMCA Facility would generate approximately 10,839 pounds of solid waste per day, or 1,979 tons per year. Per AB 939 there is a requirement to reduce the solid waste stream by 50%, which means that approximately 5,419.5 pounds of the Proposed Project's total waste stream (798 tons per year) would be diverted elsewhere than to a landfill (e.g. recycled.) Therefore, the Proposed Project is anticipated to produce approximately 5,419.5pounds per day of solid waste (71 tons total landfill capacity in the County is limited and any addition to the overall waste stream would reduce the County's overall landfill capacity. The Chiquita Canyon Landfill, the Antelope Valley Public Landfill I and II and the Lancaster Landfill and Recycling Center have sufficient capacity for | *Long-term Operational*<br>N.3-9 The Project Applicant shall locate recycling / separation areas in close proximity to dumpsters for non-recyclables, elevators, loading docks, and primary internal and external access points.<br><br>N.3-10 The Project Applicant shall locate recycling / separation areas such that they are not in conflict with any applicable federal, state or local laws.<br><br>N.3-11 The Project Applicant shall locate recycling / separation areas so they are convenient for those persons who deposit collect, and load the recyclable material. | Significant and Unavoidable |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| their currently projected solid waste intake and the Proposed Project's intake for the foreseeable short-term future. However, because local landfills will eventually reach capacity, the Proposed Project's long-term impact on solid waste facilities would be considered significant. | N.3-12 The Project Applicant shall place recycling containers / bins so that they do not block access to one another.<br><br>N.3-13 The project shall employ the use of xeriscape techniques and plant drought tolerant and native vegetation in common landscaped areas, wherever possible, to reduce yard waste.<br><br>N.3-14 For commercial and institutional developments and residential buildings having five or more dwelling units, no refuse collection or recycling areas are to be located between a street and the front of a building.<br><br>N.3-15 The project shall install on-site trash compactors for non-recyclables in all commercial (YMCA and junior high school) food service areas.<br><br>N.3-16 If possible, kitchen, garage and garden design shall accommodate trash and recyclable components to assist the City's recycling efforts. This includes a design to accommodate a minimum of three 90-gallon containers in locations allowable under the development's CC&Rs.<br><br>N.3-17 First time buyers shall receive educational material on the City's waste management efforts, including information concerning curbside recycling, used motor oil recycling, and hazardous waste collection | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | programs. Education material shall be passed on to consecutive buyers using the development's CC&Rs | |
| ***Cumulative Impacts:***<br>**Water**<br><br>The CLWA anticipates that its projected water supplies available during normal, single-dry, and multiple-dry water years, as included in its 2000 UWMP, as amended, would meet the projected water demand associated with the Proposed Project, in addition to the existing and other planned future uses in the CLWA's system.<br><br>The Water Supply Assessment for the Proposed Project included the Proposed Project and "planned future uses", which includes probable future projects. The Water Supply Assessment clarifies "planned future uses" as within the projections included in the 2000 UWMP, as amended. Therefore, the Proposed Project's incremental increase would not be considerable and impacts on water supplies would be less than significant.<br><br>The effect of the additional water connections due to the Proposed Project would not incrementally contribute a considerable amount to the cumulative total number of connections. As such, the associated cumulative impact would not be cumulatively | None required. | Less than Significant |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| considerable and impacts would be less than significant. The project's incremental increase would not be considerable and impacts would be less than significant. | | |
| Sewer<br>The design capacity of the Santa Clarita Valley Joint Sewage System (SCVJSS) is 28.10 mgd and the SCVJSS's current average wastewater flow is 18.4 mgd. Therefore, the SCVJSS has a remaining capacity of approximately 9.7 mgd. The cumulative sewage generation of 1.5 mgd would be well within the design capacity of the SCVJSS, representing about 15.5 percent of the remaining capacity. In addition, it should be noted that connection permits are not issued if there is not sufficient capacity in the system, and all new development projects are required to pay the District's connection fees to assure the continual expansion of district facilities. Therefore no project and related project impacts would be considerable and impacts to the sewerage system would be less than significant. The project's incremental increase is not considerable and impacts would be less than significant. | None required | Less than Significant |
| Solid Waste<br>The Proposed Project, in combination with the related projects, would generate a cumulative total of approximately 71,739 pounds (35.9 tons) of solid waste per day. As discussed above, new landfill options and additional capacity may become available through the expansion of the Puente Hills Landfill, conversion of waste-to-energy and through waste-by-rail programs to landfills | None required | Significant and Unavoidable |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
|---|---|---|
| outside of Los Angeles County (e.g., the proposed Eagle Mountain Landfill in Riverside County). Because solid waste (including hazardous waste) can could eventually be disposed of outside of Los Angeles County, and the disposal market is driven by the free enterprise system, it is reasonable to assume that as local options are exhausted solid waste generated by cumulative development would be disposed of outside of Los Angeles County and even possible possibly outside of the state. Given this assumption, the cumulative project area could encompass a geographic area outside the jurisdictional boundaries of the City of Santa Clarita, Los Angeles County and even possibly the state border. However it is beyond the scope of this EIR and too speculative to attempt to quantify the solid waste that could be generated by cumulative development that is proposed in greater Los Angeles County or the region beyond, or to assess the landfill options that might be available or, more importantly, other solid waste disposal options which could become available.<br><br>It is reasonable to assume that the market forces that drive the waste disposal industry will put pressure on officials and governmental agencies to continually identify new, economically and politically feasible means of waste disposal in the future to accommodate growth. However, because new facilities are not currently available, cumulative project impacts would be considered significant. The project's incremental increase would be considerable and impacts would be significant. | | |
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| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| **TRANSPORTATION** | | |
| The Proposed Project would generate approximately 11,005 total average daily trips (ADT). Approximately 1,468 and 1,009 trips would occur in the AM and PM peak hours, respectively. | *On-site Mitigation Measures*<br>O-1 The project applicant shall construct all on-site roadways and intersections to City of Santa Clarita standards.<br><br>O-2 The Proposed Project shall install a four-lane roadway on Golden Valley Road from the project's eastern boundary to the northern project boundary.<br><br>O-3 The project applicant shall install traffic signals at the following project site intersections:<br>• Golden Valley Road and "I" Street North (tee int.)<br>• Golden Valley Road and "I" Street South (four-way int.)<br>• Golden Valley Road and Ermine Street<br><br>On Golden Valley Road, a four-way intersection with "I" Street is planned approximately 0.40 miles north of the future extension of Newhall Ranch Road. This intersection will serve both the project's residential development located west of Golden Valley Road and the YMCA and junior high school site located on the east. The second intersection with Golden Valley Road at Ermine Street will be configured as a "T" intersection and will be located approximately 0.50 miles north of the four-way intersection at "I" Street. The third intersection with Golden Valley Road (the second connection to "I" street) will be located approximately 0.10 miles | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | north of the Ermine Street intersection. | |
| The project would generate approximately 513 total daily transit trips and approximately 51 peak hour transit trips. The City of Santa Clarita does not have level of service standards for transit serve that are applicable to future development. Transit service is evaluated and fueled on an as-needed basis. IF additional fixed route service will be needed near the project site in the future, the project should coordinate with the transit provider to identify appropriate bus stop/turnout locations. | *Congestion Management Program (CMP) – Transit Service*<br>O-4 The project applicant shall coordinate with the local transit provider to identify appropriate bus/stop turnout locations on the project site roadways (Golden Valley Road and/or "I" Street). | Less than Significant |
| Nine intersections experience a significant impact due to the project-generated traffic when compared to the no project scenario, and eight of those intersections forecast to exceed LOS "D". The following intersections are those significantly impacted:<br><br>Existing Intersections<br>• 57. Valencia Boulevard & Magic Mtn Parkway<br>• 65. Bouquet Canyon Road & Soledad Canyon Road<br>• 66. Bouquet Canyon Road & Newhall Ranch Road<br>• 145. Sierra Highway & Placerita Canyon Road<br>• 162. Sierra Highway & Golden Valley Road<br>• 172. Whites Canyon Road & Soledad Canyon Road<br>Future Intersections<br>• 163. Golden Valley Road & Via Princessa<br>• 166. Golden Valley Road & Newhall Ranch Road<br>Freeway On/Off Ramp Intersection | *Off-Site Mitigation*<br>Existing Intersections<br><br>O-5 (57.) Valencia Boulevard & Magic Mountain Parkway. Add second WBL turn lane. Implementation of this measure would require restriping, median modification and widening of Valencia Boulevard.<br><br>O-6 (65.) Bouquet Canyon Road and Soledad Canyon Road. Add fourth NBT lane. Implementation of this measure would require widening of Bouquet Canyon Road northbound approach.<br><br>O-7 (66.) Bouquet Canyon Road & Newhall Ranch Road.<br>- Add second SBL turn lane. Implementation of | Significant and Unavoidable (see Cross Valley Connector discussion below) |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| • 144. Sierra Highway & SR-14 SB Ramps | this measure would require restriping with potential median modification.<br>- Add second SBR turn lane. Implementation of this measure would require widening of Bouquet Canyon Road southbound approach.<br>- Add third EBT lane. Implementation of this measure would require restriping.<br><br>O-8 (145.) Sierra Highway & Placerita Canyon Road.<br>- Restripe one WBT lane to a WBR turn lane. Implementation of this measure would require restriping.<br>- Restripe one WBT lane to a shared thru/right turn lane. Implementation of this measure would require restriping.<br><br>O-9 (162.) Sierra Highway and Golden Valley Road. Add third WBT lane. Implementation of this measure would require widening of west leg (Golden Valley Road) to accommodate three lanes.<br><br>O-10 (177.) Whites Canyon Road and Soledad Canyon Road. Restripe separate WBR turn lane to a shared thru/right lane. Implementation of this measure would require restriping. This mitigation measure is only necessary for the "With Golden Valley Road extension to Plum Canyon Road" scenario, with or without the Ermine Street connection to Golden Valley Road. | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| | Future Intersections<br><br>O-11 (163.) Golden Valley Road & Via Princessa. No requirements of the project applicant. Future intersection to be built out to achieve LOS D.<br><br>O-12 (166.) Golden Valley Road & Newhall Ranch Road.<br>- Install traffic signal.<br>- Add second WBR turn lane or construct WBR as a free-flow turn lane. This mitigation measure is only necessary for the "With Golden Valley Road extension to Plum Canyon Road" scenario, with or without the Ermine Street connection to Golden Valley Road.<br><br>Freeway On/Off Ramp Intersections<br><br>0-13 (144.) Sierra Highway & SR-14 SB Ramps.<br>- Add separate NBR turn lane. Implementation of this measure would require restriping.<br>- Add second SBL turn lane. Implementation of this measure would require restriping with potential widening of Sierra Highway. | |
| Two scenarios have been analyzed in which the planned Cross | Project Mitigation is not sufficient for either scenario without the | Significant and Unavoidable |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| Valley Connector (CVC) roadway is either not built or is only partially built before the occupancy of the Proposed Project. One scenario examined only construction of the CVC east of Bouquet Canyon road to serve only the neighboring Riverpark project (recently approved by City Council). Keystone traffic would access the site via Golden Valley Road at Plum Canyon Road.<br><br>The second scenario examined the construction of the CVC to the west of the site for project access (with access as well to Plum Canyon Road on the north) but the bridge over the Santa Clara River is not completed but the Golden Valley Road/Soledad Canyon Road flyover is operational. For both scenarios, the neighboring Riverpark project is built with only 500 residential units.<br><br>Under the first scenario, eight intersection show significant impacts and under the second scenario four intersections would be significantly impacted. The following are the significantly impacted intersections:<br><br>• 48. McBean Parkway & Newhall Ranch Road (Scenario 2)<br>• 65. Bouquet Canyon Road & Soledad Canyon Road (Scenarios 1 & 2)<br>• 66. Bouquet Canyon Road & Newhall Ranch Road (Scenarios 1 & 2)<br>• 67. Seco Canyon Road & Bouquet Canyon Road (Scenario 1)<br>• 160. Haskell Canyon Road & Bouquet Canyon Road | completed Cross Valley Connector roadway. | |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| (Scenario 1)<br>• 172. Whites Canyon Road & Soledad Canyon Road (Scenario 1 & 2)<br>• 173. Santa Catarina/GVR & Plum Canyon Road (Scenario 1)<br>• 174. Bouquet Canyon Road & Plum Canyon Road (Scenario 1)<br>• 198. Valley Center & Soledad Canyon Road (Scenario 1)<br><br>Intersections of particular importance to the project for these scenarios are Bouquet Canyon Road at Plum Canyon Road and Bouquet Canyon Road at Newhall Ranch Road. Without the CVC, each of these intersections show deficiencies without project traffic added. Without the relief provided by the CVC, even a small amount of additional traffic added to these locations will result in a significant impact. Even a minimal amount of traffic from the project site results in significant impacts at the identified locations and that implementation of an early phase of The Keystone project is not feasible without the CVC. | | |
| Cumulative Impacts<br>The additional cumulative traffic, without the project, would worsen conditions at eight intersections during one or both of the peak-hour periods. With the addition of the project traffic, nine intersections experience a significant impact, and eight of those intersections forecast to exceed LOS "D". The cumulative significantly impacted intersections include: | Bouquet Canyon Bridge and Thoroughfare District<br><br>O-14 The project and related projects shall fund its calculated fair share of improvements to the Bouquet Canyon Bridge and Thoroughfare District to augment future improvements that are planned for the SR-14 freeway. | Significant and Unavoidable |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| Freeway On/Off Ramp Intersection<br>• 144. Sierra Highway & SR-14 SB Ramps (AM and PM)<br>Existing Intersections<br>• 57. Valencia Boulevard & Magic Mtn Parkway (AM and PM)<br>• 65. Bouquet Canyon Road & Soledad Canyon Road (PM)<br>• 66. Bouquet Canyon Road & Newhall Ranch Road<br>• 145. Sierra Highway & Placerita Canyon Road (AM and PM)<br>• 162. Sierra Highway & Golden Valley Road (AM and PM)<br>• 172. Whites Canyon Road & Soledad Canyon Road<br>Future Intersections<br>• 163. Golden Valley Road & Via Princessa (AM and PM)<br>• 166. Golden Valley Road & Newhall Ranch Road (PM)<br><br>Therefore, traffic would worsen at these intersections and the Proposed Project would contribute considerably to the cumulative impact at locations shown to be deficient, therefore cumulative impacts are significant. Like the Proposed Project, the related projects would be dependent upon a completed Cross Valley Connector roadway for impacts to be less than significant. | | |
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| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| ENERGY CONSERVATION | | |
| ***Electricity:***<br>Upon full build-out, the Proposed Project is anticipated to consume approximately 17,585 kilowatt hours (kwH) per day. In order to serve the Proposed Project's electricity needs, existing electrical lines in the project area would need to be extended. The SCE has determined that the electrical loads of the Proposed Project are within the parameters of projected load growth for the area and therefore there would be an adequate power supply to serve the Proposed Project.<br><br>With modern energy efficient construction materials and compliance with Title 24 standards, the Proposed Project would be consistent with the State's energy conservation standards and therefore would not conflict with adopted energy conservation plans. | P.1-1 In the event of full or partial road closures, the project developer shall employ flagmen during the construction of the electrical distribution system to facilitate the flow of traffic.<br><br>P.1-2 During the design process, the project developer shall consult with the Southern California Edison's, Energy Design Resources program or SCE's Savings by Design program, regarding additional possible energy efficiency measures.<br><br>None required. | Less than Significant<br><br>Less than Significant |
| *Cumulative Impacts:*<br><br>Development of the Proposed Project in conjunction with the 12 related projects would increase the demand for electricity. The estimated electricity consumption by the related projects in combination with the Proposed Project would be approximately 111,915 kwH per day. However, cumulative impacts are not expected to be significant as the SCE has an obligation to serve the citizens of the City and projects would be required to comply with Title 24 of the California Code which establishes energy | | |





| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| conservation standards for new construction. Therefore, the combined effects of the Proposed Project and the related projects are expected not to be cumulatively considerable and impacts would be less-than-significant. | | |
| ***Natural Gas:***<br>Upon full build-out, the Proposed Project is anticipated to consume approximately 153,943 cubic feet of natural gas per day. SCG has stated that it can accommodate the natural gas needs of the Proposed Project from existing medium pressure mains and current supply. Natural gas would likely be provided to the project site by providing service extensions from the four-inch medium pressure main in Ermine Street and an additional extension from either Newhall Ranch Road and/or Golden Valley Road. While the extension of natural gas service to the Proposed Project would include expansion of distribution infrastructure and capacity-enhancing alterations to existing facilities, these requirements are not expected to create significant impacts to the physical environment as there would be no disruption in service to existing customers; extension of natural gas mains would be within public right-of-ways and any required road closures would be for a short period of time; and the full cost of the proposed service extensions and the fair share costs of the expansion of the natural gas distribution systems would be borne by the project developer.<br><br>In addition, the Proposed Project would comply with the standards in Title 24 as they relate to the conservation of natural gas and would use modern energy-efficient construction materials and | P.2-1 Prior to the start of construction, the Proposed Project's energy engineer shall consult with SCG for an energy analysis regarding efficiency and conservation measures.<br><br>P.2-2 The project developer shall hire flagmen to facilitate traffic flow during installation of the natural gas main extensions. | Less than Significant |

| PROJECT IMPACTS | MITIGATION MEASURES | LEVEL OF IMPACT AFTER MITIGATION |
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| otherwise comply with the State's energy conservation standards. Therefore, the Proposed Project would not conflict with adopted energy conservation plans. | | |
| | | |
| *Cumulative Impacts:*<br><br>Development of the Proposed Project in conjunction with the 12 related projects would increase the demand for natural gas. The estimated natural gas consumption by the related projects in combination with the Proposed Project would be approximately 1,161,805 cubic feet per day. However, cumulative impacts are not expected to be significant because SCG has stated that "[d]emand projections by the Gas Company have allowed for additional load/demand of this project, as well as, the cumulative impact of future proposals in this area." As SCG has indicated that natural gas is available for the Proposed Project in combination with the related projects, cumulative impacts to natural gas services would not be cumulatively considerable and impacts would be less than significant | None required | Less than Significant |



Pages omitted.
Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

# V. ENVIRONMENTAL IMPACT ANALYSIS
# N. UTILITIES
# 1. WATER

## INTRODUCTION

This section addresses the potential environmental impacts associated with the provision of water to the Proposed Project. In accordance with Sections 10910-10915 of the State Water Code, a Water Supply Assessment was conducted for the Proposed Project. The Water Supply Assessment for the Proposed Project is discussed in detail below, and is attached as Appendix 10 to this Draft EIR.

## ENVIRONMENTAL SETTING

### Physical Conditions

#### *Regional Climate*

The climate in the Santa Clarita Valley is characterized as semi-arid and warm. Temperatures in the summer months can reach up to approximately 110 degrees Fahrenheit, and temperatures in the winter months can drop to approximately 20 degrees Fahrenheit. Average annual rainfall is approximately 18 inches in the flat-lying areas and approximately 27 inches in the mountainous areas. The region is subject to wide variations in precipitation.[1]

#### *Regional Geology and Hydrology*

The project site is located in the 103-square-mile Santa Clara River Valley Groundwater East Subbasin (see Figure V.N.1-1), which is bounded by the Piru Mountains to the north, the Modelo and Saugus Formations and alluvium to the west, the Santa Susana Mountains to the south, and the Gabriel Mountains to the southeast. The subbasin is drained by the Santa Clara River, Bouquet Creek, and Castaic Creek.[2]

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[1] *Castaic Lake Water Agency, Urban Water Management Plan 2000, page 1-6.*

[2] *California Department of Water Resources, California Groundwater Bulletin 118, Hydrologic Region South Coast, Santa Clara River Valley Groundwater Basin, February 27, 2004.*





In the Santa Clara River Valley, groundwater is found in alluvium, terrace deposits, and the Saugus Formation. Generally, groundwater in the subbasin is unconfined in the alluvium (i.e., Alluvial Aquifer), but may be confined, semi-confined, or unconfined in the Saugus Formation.[3]

Groundwater levels in the alluvium were relatively stable from 1970 through 2000, with varying depths to groundwater from approximately 13 to 100 feet depending on the location within the subbasin. Water levels tend to follow long-term precipitation patterns by dropping in period of low rainfall and recovering during periods of high rainfall. Groundwater levels in the Saugus Formation were also constant between 1970 and 2000. Groundwater flow in the subbasin is southward and westward, following the course of the Santa Clara River.[4]

#### *Aquifer Recharge*

The Alluvial Aquifer is recharged chiefly by infiltration of runoff in the Santa Clara River and its tributaries, with additional natural recharge from precipitation to the valley floor and subsurface flow. Recharge is also attributed to excess irrigation water that is used in urban landscaping and reclaimed water discharged into the Santa Clara River. From the sands and gravels beneath the Santa Clara River, water is pumped from relatively shallow wells (up to 200 feet in depth). The Alluvial Aquifer is estimated to store over 200,000 acre-feet of water.[5]

Beneath the Alluvial Aquifer, the Saugus Formation is a deeper layer of groundwater. Recharge to the Saugus Formation is from precipitation on the exposed formation and percolation of water from the alluvial aquifer. It is estimated that the Saugus Formation stores about one million acre-feet of water and is pumped by wells extending to about 2,000 feet in depth.[6] Water is discharged through pumping for municipal irrigation, consumption by vegetation, and outflow to the Santa Clara River.

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[3] *Ibid.*

[4] *Ibid.*

[5] *Castaic Lake Water Agency, Urban Water Management Plan 2000, page 1-12*

[6] *Ibid.*

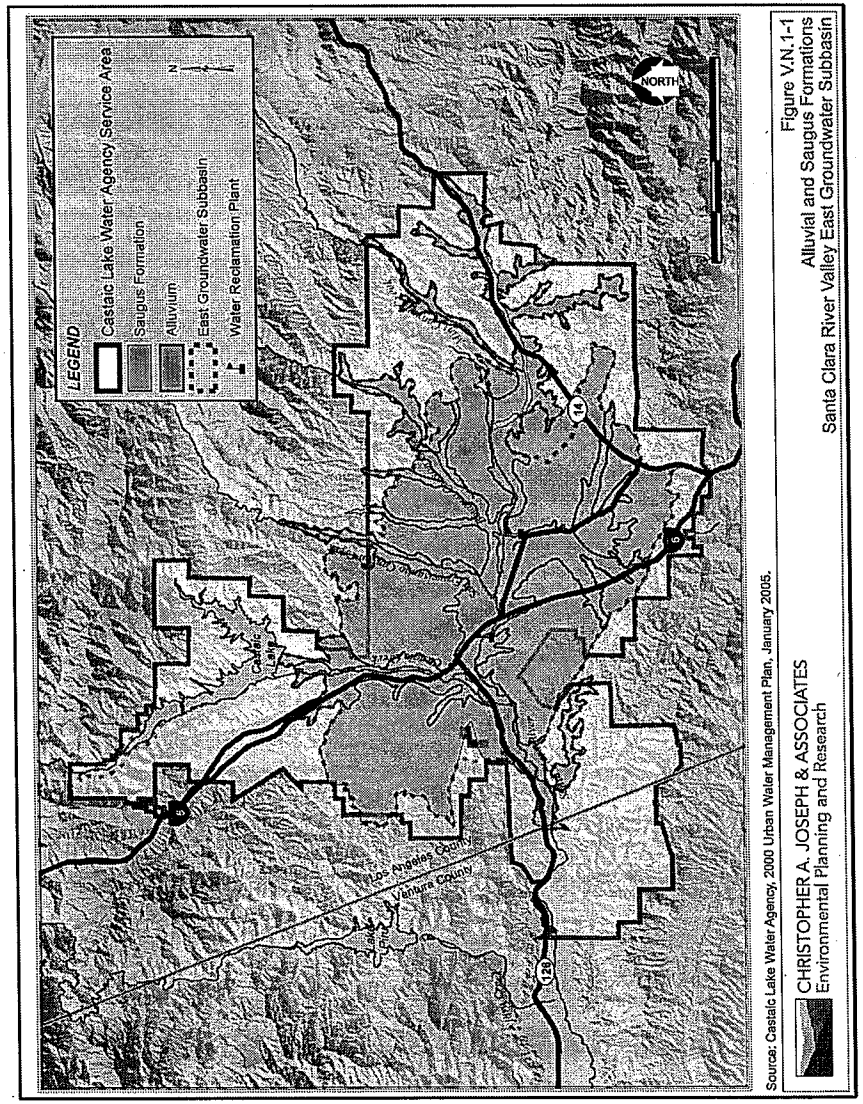


Figure V.N.1-1
Alluvial and Saugus Formations
Santa Clara River Valley East Groundwater Subbasin



***Local Geology and Hydrology***

Groundwater beneath the project site is found in the recent alluvium (i.e., Alluvial Aquifer), and perched above the Saugus Formation and the Quaternary Terrace Deposits. Detailed information regarding the geology of the project site is presented in Section V.F, Geology and Soils, of this Draft EIR. Detailed information regarding the hydrology of the project site is presented in Section V.H, Hydrology and Water Quality, of this Draft EIR.

***Cyclic Drought Conditions***

Local droughts in the Santa Clarita Valley historically have resulted in short-term increased water demand, short-term increased groundwater pumping, and short-term decreased recharge to the local groundwater system.

Statewide drought affects water availability in the SWP system, and ultimately deliveries from the State Water Project (SWP) system. Droughts have occurred locally in 1947-1950, 1958-1960 and 1990-1991. Recent Statewide droughts have occurred in 1976-1977 and 1987-1992.[7] Since the area's water supplies are dependent on rainfall conditions both locally and Statewide, it is important to note that wet and dry year conditions do not occur at the same time in Northern and Southern California. As a result, the water purveyors in Santa Clarita Valley are able to adjust the mix of available water resources on a year-to-year basis in response to local and Statewide hydrologic conditions.

Prior to 1990-1991, Statewide drought conditions had a minimal impact upon the Santa Clarita Valley, other than requiring additional water supply to compensate for the lack of spring rainfall for irrigation (e.g., crops, lawns and gardens). In 1990-1991, however, for the first time, Statewide drought conditions caused cutbacks in imported SWP supplies in the Santa Clarita Valley. Water production also declined in some wells operating in the shallow, outlying reaches of the Alluvial Aquifer. However, because Santa Clarita Water Division's (SCWD) alluvial wells are located in the major water bearing reaches of the aquifer, none of SCWD's alluvial wells experienced loss of production during 1990-1991. In addition to the alluvial groundwater supplies, the water purveyors in Santa Clarita Valley pumped more water from the Saugus Formation in 1990-1991, and requested that their

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[7] *The 1987-1992 drought was notable for its six-year duration. Statewide reservoir storage was about 40 percent of average by the third year of the drought. The SWP met contractors' delivery requests during the first four years of the drought, but then was forced by declining reservoir storage to reduce deliveries substantially. The SWP terminated deliveries to agricultural contractors and provided about 30 percent of requested urban deliveries in 1991, the single driest year of the drought. A 1991 Governor's executive order resulted in implementation of a State drought water bank. (Critical Water Shortage Contingency Plan, Governor's Advisory Drought Planning Panel, December 29, 2000.)*

customers voluntarily conserve water by 10 percent. Actual water use in the valley decreased more than 10 percent as a direct result of water conservation efforts.

Due to the steps taken by the local purveyors, water demands in the Santa Clarita Valley were met for the duration of the 1990-1991 drought. CLWA also elected not to participate in the State's Drought Water Bank because alternate local supplies were available to meet water demands in the Santa Clarita Valley. In addition, members of the Santa Clarita Valley Water Purveyors signed a Drought Emergency Water Sharing Agreement, agreeing to share water from all sources, and to facilitate beneficial water transfers, exchanges and wheeling arrangements. The purveyors also worked with the City of Santa Clarita and the County of Los Angeles to implement water use ordinances for Santa Clarita Valley residences, review water consumption and supply data and recommend measures to encourage conservation.

Since the 1990-1991 drought, CLWA and the other retail water purveyors have continued to work cooperatively to ensure customer demands are met under varying hydrologic conditions and with overall increasing demands from planned growth. These efforts have included water resource planning activities, acquisition of new water supplies and construction of transmission and treatment facilities. These efforts include the decision by most of the Santa Clarita Valley's water agencies to jointly prepare the Urban Water Management Plan (UWMP). The UWMP describes current and future implementation of water conservation measures (called "Water Demand Management Measures") within the CLWA service area. The UWMP also includes an update to the Santa Clarita Valley's Critical Water Shortage Contingency Plan. The updated plan is based on the water agencies' actual experience in addressing water shortages in the Santa Clarita Valley in 1991 (due to the continuation of the 1990-1991 Statewide drought) and in 1994 (due to the 1994 Northridge earthquake).

**Water Use and Planning**

***Water Purveyors***

*Castaic Lake Water Agency*

The Castaic Lake Water Agency (CLWA) was formed in 1962 as a wholesale water agency whose purpose it was to contract with the California Department of Water Resources (DWR) to provide supplemental water supply from the State Water Project (SWP) to retail water purveyors in the Santa Clarita Valley. CLWA obtains SWP water from the upper reservoir in Castaic Lake. CLWA serves the City of Santa Clarita, the unincorporated Santa Clarita Valley in Los Angeles County, and portions of unincorporated Ventura County. The CLWA service area encompasses approximately 195 square miles.





*Retail Purveyors*

The CLWA and the following four retail water purveyors provide water to most residents in the Santa Clarita Valley.

- **Los Angeles County Waterworks District 36.** The Los Angeles County Waterworks District 36 (the "District") service area encompasses approximately 7,635 acres in the Hasley Canyon area and the unincorporated community of Val Verde. The District obtains all of its water supply from the CLWA, and does not have any currently operating groundwater extraction facilities.

- **Newhall County Water District.** The Newhall County Water District (NCWD) service area includes Newhall, Pinetree, Tesoro Del Valle, and Castaic. The NCWD has service connections that extend over a 35-square-mile area. The NCWD obtains all of its water supply from groundwater wells and SWP water from the CLWA.

- **Santa Clarita Water Division.** The CLWA's Santa Clarita Water Division (SCWD) service area includes portions of the City of Santa Clarita and portions of the unincorporated communities of Saugus, Canyon Country, and Newhall. The SCWD obtains all of its water supply from the CLWA. The SCWD would be the water purveyor for the Proposed Project.

- **Valencia Water Company.** The Valencia Water Company (VWC) service area encompasses approximately 25 square miles and includes a portion of the City of Santa Clarita and portions of the unincorporated communities of Castaic, Stevenson Ranch, and Valencia. The VWC obtains all of its water supply from groundwater wells and SWP water from the CLWA.

The CLWA and the retail water purveyors' service areas are illustrated in Figure V.N.1-2.

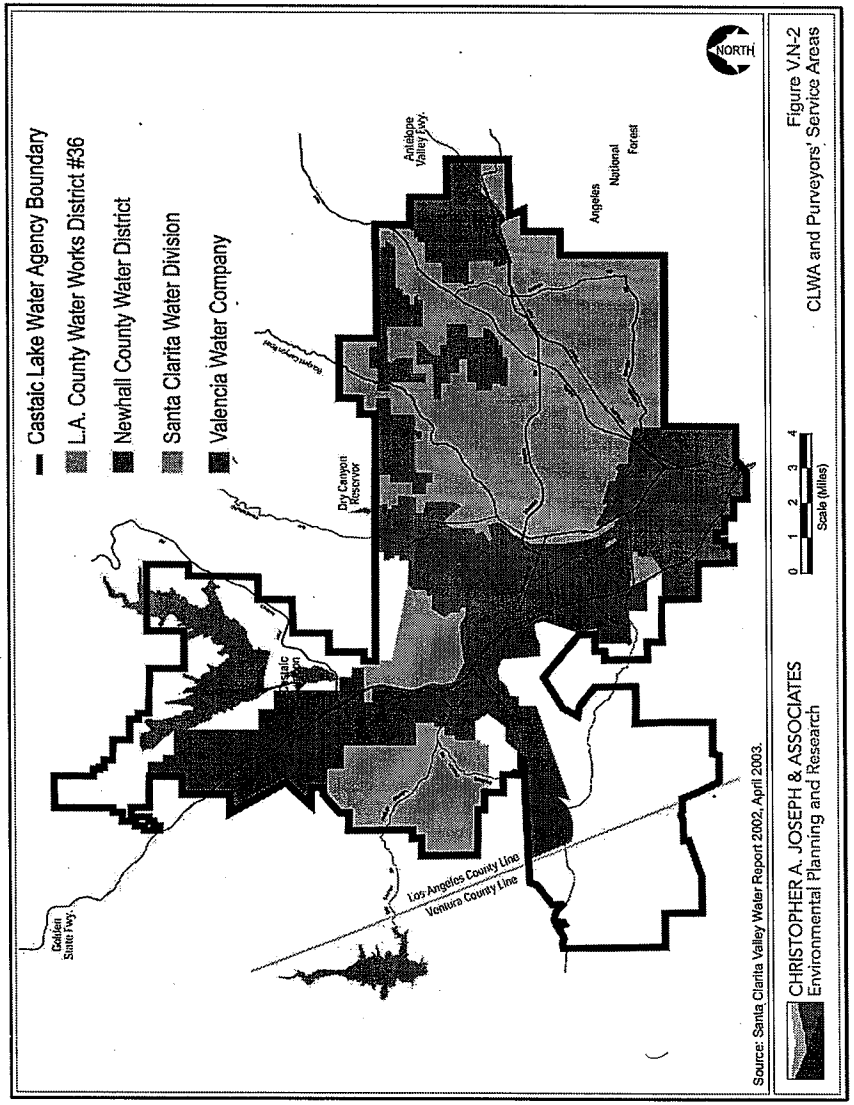


Figure V.N-2
CLWA and Purveyors' Service Areas



**Water Supply Facilities and Water Treatment Facilities**

CLWA's water treatment facilities include the Earl Schmidt Filtration Plant and the Rio Vista Water Treatment Plant. The Earl Schmidt Filtration Plant has a capacity of 33 million gallons per day (gpd) of water, and the Rio Vista Water Treatment Plant has a capacity of 30 million gpd of water. The Earl Schmidt Filtration Plant is currently being expanded to a capacity of approximately 56 million gpd by Spring-2005.[8]

From CLWA's two water treatment facilities, water is distributed by gravity to the retail water purveyors through a network of pipelines and turnouts. Local water retailers combine this water with groundwater from municipal supply wells in the Alluvial Aquifer and the Saugus Formation.

With respect to water supply facilities, the four retail water purveyors service nearly 62,000 connections in the Santa Clarita Valley in 2003. Table V.N.1-1 lists the connections by water purveyor.

**Table V.N.1-1**
**Santa Clarita Valley Water Connections**

| Retail Water Purveyor | Connections |
|---|---|
| Santa Clarita Water Division of CLWA | 25,175 |
| Los Angeles County Waterworks District 36 | 1,280 |
| Newhall County Water District | 8,650 |
| Valencia Water Company | 26,810 |
| ***Total*** | ***61,915*** |

*Source: Castaic Lake Water Agency, Groundwater Perchlorate Contamination Amendment and Other Amendments 2000 Urban Water Management Plan, January 2005.*

***Existing Water Supplies and Demand***

CLWA is currently allocated 95,200 acre-feet (i.e., approximately 31,021 million gallons[9]) of water per year. In addition, the CLWA annually receives approximately 30,000 to 40,000 acre-feet of water from the Alluvial Aquifer and approximately 4,000 to 5,000 acre-feet of water from the Saugus Formation.[10] Although historical pumping from the Saugus Formation has ranged as high as 15,000

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[8] *Castaic Lake Water Agency, Castaic Lake Water Agency FY 2004/05 Budget, July 1, 2004, page 5.*

[9] *One acre-foot is 325,851 gallons.*

[10] *Castaic Lake Water Agency, Groundwater Perchlorate Contamination Amendment and Other Amendments, 2000 Urban Water Management Plan, January 2005, page 1-4.*

acre-feet per year, the combination of recent perchlorate contamination (see Water Quality discussion below regarding perchlorate contamination) and planned use of this aquifer primarily for dry-year water supply has resulted in less pumping.

CLWA's allocation to the retail water purveyors is based on a "first come, first served" method. The CLWA distributes imported water supplies to the water service areas in a way that allows imported water to be delivered to the areas where it is needed. Developer impact fees and other types of contributions that fund CLWA's Capital Program are collected within each water service area and paid to the CLWA. However, historically, the CLWA has not been required to allocate water to the retail purveyors using this method because the available water supply has been more than sufficient to meet the purveyors' requests.

*Water Quality*

Although the overall quality of groundwater in the Santa Clarita Valley is considered to be good, ammonium perchlorate ("perchlorate") was discovered in 1997 in four groundwater wells in the Saugus Formation at a site formerly occupied by a local industry (i.e., the Whittaker-Bermite site). These four wells were immediately shut down. These four wells have a combined capacity of 9,000 gallons per minute, which represents approximately 14,500 acre-feet per year.[11] Subsequently, in November 2002, perchlorate was detected in a single Alluvial Aquifer well adjacent to the Whittaker-Bermite site (near the Saugus Speedway), which was immediately closed. In March 2005, perchlorate was detected in another Alluvial Aquifer well (known as "Q2") located immediately northwest of the confluence of Bouquet Creek and the Santa Clara River, which was immediately closed.[12]

Perchlorate is an inorganic chemical that is used in solid rocket propellants, fireworks, and explosives. Perchlorate can interfere with the ability of the thyroid gland to utilize iodine which produces thyroid hormones. Thyroid hormones are needed for normal prenatal and postnatal growth and development in children, and for normal metabolic function in adults.[13]

In the case of the Whittaker Bermite site, this 988.6-acre industrial site was used for approximately 80 years as a military flare and munitions manufacturing facility. As a result, the site was contaminated with various chemical compounds, including perchlorate which traveled downward into the

[11] *Ibid.*

[12] *Valencia Water Company, Impact and Response to Perchlorate Contamination Valencia Water Company Well Q2, prepared by Ludhorff & Scalmanini Consulting Engineers, April 2005.*

[13] *Castaic Lake Water Agency, Perchlorate Information, website: http://www.clwa.org/perchlorate_information.htm, December 21, 2004.*





groundwater and, thus, into the local drinking water supply.[14]

As perchlorate dissolves easily in water, it presents health concerns and the California Office of Environmental Health Hazard Assessment (OEHHA) has proposed a Public Health Goal for the amount of perchlorate in drinking water. OEHHA's suggests a range of two to six micrograms per liter. In addition, the California Department of Health Services (DHS) was required to adopt a Maximum Contaminant Level (MCL) for perchlorate by January 1, 2004. However, this date has been extended into 2005, and there is presently no drinking water standard, or MCL, for perchlorate. The current perchlorate advisory action level is six micrograms per liter, which is not an enforceable standard.[15]

In November 2002, the State Department of Toxic Substances Control (DTSC) issued an Order that required Whittaker to complete all site investigations and feasibility studies for all contaminants of concern expeditiously. In response to DTSC's Order, a substantial amount of cleanup work has occurred since December 2002. In summary, recent activities included:

- Additional remedial investigations, including soil samples, borings, exploratory trenching and groundwater monitoring wells;
- Feasibility reports, treatability studies and pilot tests; and
- Remedial action plans.

In addition, in September 2004, a State appellate court invalidated the Santa Clarita Valley UWMP because the plan did not "assess the reliability of the water supply obtained from two layers of an aquifer contaminated with perchlorate."[16] The court concluded that the UWMP's description of the contaminated groundwater was inadequate because it did not (1) address the time needed to treat the contaminated groundwater and (2) describe the reliability of the groundwater supply during the cleanup process. As a result, the CLWA prepared an amendment to their 2000 UWMP ("2000 UWMP Amendment") to address the concerns raised by the court.[17] However, the 2000 UWMP Amendment

[14] *City of Santa Clarita, Whittaker-Bermite Property Clean-Up Information Page, website: http://www.santa-clarita.com/cityhall/ped/planning/bermite.asp, December 28, 2004.*

[15] *Castaic Lake Water Agency, Groundwater Perchlorate Contamination Amendment and Other Amendments, 2000 Urban Water Management Plan, January 2005, page 2-24.*

[16] *Friends of the Santa Clara River et al. v. Castaic Lake Water Agency, filed September 22, 2004.*

[17] *Castaic Lake Water Agency, Groundwater Perchlorate Contamination Amendment and Other Amendments, 2000 Urban Water Management Plan, January 2005.*

was prepared prior to the detention of perchlorate in Well Q2, as discussed above. To address the contamination of Well Q2, the VWC prepared "Impact and Response to Perchlorate Contamination Valencia Water Company Well Q2."[18] Furthermore, a 2005 UWMP is currently being prepared and is expected to be completed in mid-2005, which will update both the 2000 UWMP and the 2000 UWMP Amendment.

*Re-estimated Water Supplies and Demand*

2000 UWMP Amendment

The 2000 UWMP Amendment addresses the amount of water supply available while planning, design, and construction of treatment and other restoration activities are being implemented, as well as long-term water supply. As such, the 2000 UWMP Amendment presents the following two sets of operational scenarios: (1) near-term conditions (2005-2007) to include the transition of local groundwater supplies from impacted to restored and (2) long-term conditions (through 2020) through the end of the planning horizon. The estimated water supply and demand for the near-term and long-term operational scenarios during an average/normal water year is presented in Table V.N.1-2 and Table V.N.1-3, respectively, below. As shown in both tables, the combination of existing and planned water supplies will be able to meet projected water demand in an average/normal water year.

**Table V.N.1-2**
**Water Supply and Demand -Near-Term Operational Scenario**
**Average/Normal Water Year (acre-feet)**

| Existing Water Supply | 2005 | 2006 | 2007 |
|---|---|---|---|
| **Local Supplies** | | | |
| Alluvial Aquifer | 35,000 | 35,000 | 35,000 |
| Saugus Formation | 5,000 | 5,000 | 9,000 |
| Recycled Water | 700 | 1,000 | 1,300 |
| **Imported Supplies** | | | |
| SWP Table A Amount | 41,000 | 42,380 | 39,760 |
| Draw From Short-Term Semitropic Bank Account | 0 | 0 | 0 |
| Draw From Flexible Storage Account | 0 | 0 | 0 |
| ***Total Existing Supply*** | ***81,700*** | ***83,380*** | ***85,060*** |
| ***Estimated Demand (without conservation)*** | ***81,700*** | ***83,380*** | ***85,060*** |
| *Source: Castaic Lake Water Agency, 2000 Urban Water Management Plan, January 2005, Table 4-1.* | | | |

[18] *Valencia Water Company, Impact and Response to Perchlorate Contamination Valencia Water Company Well Q2, prepared by Ludhorff & Scalmanini Consulting Engineers, April 2005.*





**Table V.N.1-3**
**Water Supply and Demand - Long-Term Operational Scenario**
**Average/Normal Water Year (acre-feet)**

| Existing Water Supply | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| **Local Supplies** | | | | |
| Alluvial Aquifer | 35,000 | 35,000 | 35,000 | 35,000 |
| Saugus Formation | 5,000 | 11,000 | 11,000 | 11,000 |
| Recycled Water | 700 | 1,700 | 1,700 | 1,700 |
| **Imported Supplies** | | | | |
| SWP Table A Amount | 41,000 | 56,800 | 56,800 | 56,800 |
| Draw From Short-Term Semitropic Bank Account | 0 | 0 | 0 | 0 |
| Draw From Flexible Storage Account | 0 | 0 | 0 | 0 |
| ***Total Existing Supply*** | ***81,700*** | ***104,500*** | ***104,500*** | ***104,500*** |
| **Planned Water Supply** | **2005** | **2010** | **2015** | **2020** |
| **Local Supplies** | | | | |
| Recycled Water | 0 | 7300 | 12,300 | 15,300 |
| **Imported Supplies** | | | | |
| Draw From Long-Term Water Banking Programs | 0 | 0 | 0 | 0 |
| ***Total Planned Supply*** | ***0*** | ***7,300*** | ***12,300*** | ***15,300*** |
| **Total Supply (Existing plus Planned)** | **81,700** | **111,800** | **116,800** | **119,800** |
| **Estimated Demand (Without Conservation)** | **81,700** | **90,100** | **100,700** | **113,100** |
| *Source: Castaic Lake Water Agency, 2000 Urban Water Management Plan, January 2005, Table 4-3.* | | | | |

With respect to a dry year and multiple-dry year, as shown in Table V.N.1-4 and Table V.N.1-5, the existing and planned supplies would meet projected demands in both near-term and long-term conditions. As shown in both tables, the combination of existing and planned water supplies will be able to meet projected water demand in a single-dry year and multiple-dry water years.

**Table V.N.1-4**
**Water Supply and Demand - Near-Term Operational Scenario**
**Single Dry Year and Multiple-Dry Year (acre-feet)**

| | Single Dry Year | Multiple Dry Years | | |
|---|---|---|---|---|
| Existing Water Supply | 2005 | 2005 | 2006 | 2007 |
| **Local Supplies** | | | | |
| Alluvial Aquifer | 32,500 | 32,500 | 32,500 | 32,500 |
| Saugus Formation | 5,000 | 5,000 | 5,000 | 11,000 |
| Recycled Water | 700 | 700 | 1,000 | 1,300 |
| **Imported Supplies** | | | | |
| SWP Table A Amount | 37,940 | 37,900 | 37,900 | 37,900 |
| Draw From Short-Term Semitropic Bank Account | 916 | 4,039 | 5,419 | 2,360 |

**Table V.N.1-4**
**Water Supply and Demand - Near-Term Operational Scenario**
**Single Dry Year and Multiple-Dry Year (acre-feet)**

| Existing Water Supply | Single Dry Year | Multiple Dry Years | | |
|---|---|---|---|---|
| | 2005 | 2005 | 2006 | 2007 |
| Draw From Flexible Storage Account | 4,684 | 1,561 | 1,561 | 0 |
| ***Total Existing Supply*** | ***81,700*** | ***81,700*** | ***83,380*** | ***85,060*** |
| ***Estimated Demand (without conservation)*** | ***81,700*** | ***81,700*** | ***83,380*** | ***85,060*** |

*Source: Castaic Lake Water Agency, 2000 Urban Water Management Plan, January 2005, Table 4-2.*

**Table V.N.1-5**
**Water Supply and Demand - Long-Term Operational Scenario**
**Single Dry Year and Multiple-Dry Year (acre-feet)**

| Existing Water Supply | Single Dry Year | Multiple Dry Years | | |
|---|---|---|---|---|
| | 2010 | 2018 | 2019 | 2020 |
| **Local Supplies** | | | | |
| Alluvial Aquifer | 32,500 | 32,500 | 32,500 | 32,500 |
| Saugus Formation | 15,000 | 15,000 | 15,000 | 15,000 |
| Recycled Water | 1,700 | 1,700 | 1,700 | 1,700 |
| **Imported Supplies** | | | | |
| SWP Table A Amount | 37,900 | 37,900 | 37,900 | 37,900 |
| Draw From Short-Term Semitropic Bank Account (through 2013) | 17,500 | 0 | 0 | 0 |
| Draw From Flexible Storage Account | 4,684 | 1,561 | 1,561 | 1,561 |
| ***Total Existing Supply*** | ***109,284*** | ***88,661*** | ***88,661*** | ***88,661*** |
| **Local Supplies** | | | | |
| Restored Contaminated Wells | 10,000 | 10,000 | 10,000 | 10,000 |
| New Saugus Wells | 0 | 0 | 0 | 10,000 |
| Recycled Water | 7,300 | 12,300 | 12,300 | 15,300 |
| **Imported Supplies** | | | | |
| Draw From Long-Term Water Banking Programs | 20,000 | 13,000 | 13,000 | 13,000 |
| ***Total Planned Supply*** | ***37,300*** | ***35,300*** | ***35,300*** | ***48,300*** |
| **Total Supply (Existing plus Planned)** | **146,584** | **123,961** | **123,961** | **136,961** |
| **Estimated Demand (Without Conservation)** | **90,100** | **108,140** | **110,620** | **113,100** |

*Source: Castaic Lake Water Agency, 2000 Urban Water Management Plan, January 2005, Table 4-4.*





Effect of Perchlorate Contamination in Well Q2 on Water Supply

As discussed above, perchlorate was detected in Well Q2 in March 2005. As a result of the detection of perchlorate in Well Q2, the VWC has removed it from active service and is pursuing rapid permitting and installation of wellhead treatment in order to return the well to water supply service. It is anticipated that the permitting and installation of wellhead treatment can be accomplished by mid-summer 2005, in advance of the peak water demand season. Nonetheless, the VWC assessed the effect of the removal of this well on its overall water supply until the proposed treatment is in place and the well is returned to service.[19]

The temporary closure of Well Q2 represents a reduction of 1,200 gallons per minute (gpm) of source capacity. With that closure, VWC would still operate 19 wells, including four wells in the Alluvial Aquifer and five wells in the Saugus Formation. The combined pumping capacity of the 14 wells in the Alluvial Aquifer is slightly greater than 20,000 gpm, and the combined pumping capacity of the five wells in the Saugus Formation is slightly greater than 10,000 gpm. Therefore, the combined source capacity of VWC's active wells, after the temporary closure of Well Q2, and its CLWA turnouts is approximately 57,000 gpm.[20]

With a total source capacity of approximately 57,000 gpm, with the temporary closure of Well Q2, the VWC has sufficient source capacity to meet its maximum day demand of 32,500 gpm with allowance for potential outage at one or more individual wells or treated surface water connections. Furthermore, the VWC has sufficient surplus source capacity to meet future increases in maximum day demand with existing sources, to be increased by returning Well Q2 to service after installation of treatment.[21] Therefore, considering that Well Q2 would be returned to service prior to the implementation of the Proposed Project, the temporary closure of Well Q2 would not alter the assessment of overall water supply presented in the 2000 UWMP Amendment or in the Water Supply Assessment, as described below. Furthermore, as discussed above, it is anticipated that the SCWD would be the water purveyor for the Proposed Project, not the VWC.

***Reclaimed Water Supplies and Demand***

Water reclamation is the process of treatment and cleaning of wastewater so that it can be reused for non-potable purposes (e.g., landscaping, industrial processes, and groundwater replenishment). Under

[19] *Ibid.*

[20] *Ibid.*

[21] *Ibid.*

certain conditions, the State requires the use of reclaimed water when it is available. Section 65602 of the California Government Codes states the following:

> *(a) The waters of the state are of limited supply and are subject to ever-increasing demands.*
>
> *(b) The continuation of California's economic prosperity is dependent on adequate supplies of water being available for future uses.*
>
> *(c) It is the policy of the state to promote the efficient use of water through the development of water recycling facilities.*
>
> *(d) Landscape design, installation, and maintenance can and should be water efficient.*
>
> *(e) The use of potable domestic water for landscaped areas is considered a waste or unreasonable use of water within the meaning of Section 2 of Article X of the California Constitution if recycled water is available that meets the conditions described in Section 13550 of the Water Code.*

The Sanitation Districts of Los Angeles County operate two water reclamation plants that treat wastewater in the Santa Clarita Valley, the Saugus Water Reclamation Plant (SWRP) and the Valencia Water Reclamation Plant (VWRP). The SWRP provides primary, secondary, and tertiary treatment for seven million gallons of wastewater per day[22] (2,555 million gallons per year). In Fiscal Year 2001-02 (the most recent data available), the SWRP reclaimed approximately 6,162 acre-feet of water[23] (2,008 million gallons). In addition, the VWRP provides primary, secondary, and tertiary treatment for 11 million gallons of wastewater per day[24] (4,015 million gallons per year). In Fiscal Year 2001-02, the VWRP reclaimed approximately 13,186 acre-feet of water[25] (4,297 million gallons). As of 2003, it was

[22] *Sanitation Districts of Los Angeles County, Saugus Water Reclamation Plant, website: http://www.lacsd.org/waswater/wrp/saugus.htm, December 23, 2004.*

[23] *Sanitation Districts of Los Angeles County, Water Reuse Summary for Fiscal Year 2001-2002, website: http://www.lacsd.org/waswater/webreuse/refy0002.htm, December 23, 2004.*

[24] *Sanitation Districts of Los Angeles County, Valencia Water Reclamation Plant, website: http://www.lacsd.org/waswater/wrp/valencia.htm, December 23, 2004.*

[25] *Sanitation Districts of Los Angeles County, Water Reuse Summary for Fiscal Year 2001-2002, website: http://www.lacsd.org/waswater/webreuse/refy0002.htm, December 23, 2004.*





anticipated that the CLWA will deliver approximately 1,700 acre-feet (554 million gallons) of reclaimed water annually.[26]

## ENVIRONMENTAL IMPACTS

### Thresholds of Significance

In accordance with Appendix G to the State CEQA Guidelines, a project would have a significant impact if it would:

> b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental effects;
>
> d) Have insufficient supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed;

### Project Impacts

The Proposed Project includes the development of 979 residential units, comprised of 96 single-family residences, 216 apartments, and 667 condominiums. A junior high school, a YMCA recreational facility, trails, and open space (debris basins, graded lots, and natural open space lots) are also included with the Proposed Project. A 41-foot high entry monument with a 16-foot high water feature is proposed at the entrance to the project site. Section IV, Project Description, of this Draft EIR provides a detailed discussion of the characteristics of the Proposed Project.

#### *Water Supply Assessment*

In 2001, the California State Legislature approved Senate Bill 610, which amended Sections 10910-10915 of the State Water Code to require:

> *...a city or county that determines a project is subject to the California Environmental Quality Act to identify any public water system that may supply water for the project and to request those public water systems to prepare a specified water supply assessment, except as otherwise specified. The bill would require the assessment to include, among other information, an identification of existing water supply entitlements, water rights, or water service contracts relevant to the identified water*

[26] *Castaic Lake Water Agency, Los Angeles County Waterworks District # 36, Newhall County Water District, and Valencia Water Company, Santa Clarita Valley Water Report 2002, April 2003, page 28.*

*supply for the Proposed Project and water received in prior years pursuant to those entitlements, rights, and contracts. The bill would require the city or county, if it is not able to identify any public water system that may supply water for the project, to prepare the water supply assessment after a prescribed consultation. The bill would revise the definition of "project," for the purposes of these provisions, and make related changes.*[27]

Section 10912(a) of the State Water Code defines a "project" for purposes of determining whether a Water Supply Assessment would be required as:

*(1) A proposed residential development of more than 500 dwelling units.*

*(2) A proposed shopping center or business establishment employing more than 1,000 persons or having more than 500,000 square feet of floor space.*

*(3) A proposed commercial office building employing more than 1,000 persons or having more than 250,000 square feet of floor space.*

*(4) A proposed hotel or motel, or both, having more than 500 rooms.*

*(5) A proposed industrial, manufacturing, or processing plant, or industrial park planned to house more than 1,000 persons, occupying more than 40 acres of land, or having more than 650,000 square feet of floor area.*

*(6) A mixed-use project that includes one or more of the projects specified in this subdivision.*

*(7) A project that would demand an amount of water equivalent to, or greater than, the amount of water required by a 500 dwelling unit project.*

As the Proposed Project includes the development of 979 residential units, a Water Supply Assessment was sought from the CLWA. The Water Supply Assessment for the Proposed Project is included as Appendix 10 to this Draft EIR. In its Water Supply Assessment, the CLWA concluded that the water demand generated by the Proposed Project falls within the available and projected water supplies for normal, single-dry, and multiple-dry years through 2020 (see Table V.N.1-6), and within the 20-year water demand growth projected in CLWA's 2000 UWMP , as amended. As a result, the CLWA found that it would be able to meet the water demand of the Proposed Project, in addition to existing and planned future demands of the water system.

[27] *Senate Bill 610, Legislative Counsel's Digest.*





**Table V.N.1-6**
**Existing and Planned Water Supplies Through 2020**
**(acre-feet)**

| | Available During Average Year | Available During Wet Year | Available During Single Dry Year | Available During Each of Three Consecutive Dry Years |
|---|---|---|---|---|
| **Existing Water Supplies (2004)** | | | | |
| ***Local Supplies*** | | | | |
| Alluvial Aquifer | 35,000 | 40,000 | 32,500 | 32,500 |
| Saugus Formation | 11,000 | 11,000 | 15,000 | 24,000 |
| Recycled Water | 1,700 | 1,700 | 1,700 | 1,700 |
| ***Imported Supplies*** | | | | |
| SWP Table A Amount[a] | 56,800 | 95,200 | 37,900 | 37,900 |
| Draw From Short-Term Semitropic Bank Account (through 2013) | 0 | 0 | 50,870 | 16,950 |
| Draw From Flexible Storage Account | 0 | 0 | 4,684 | 1,561 |
| **Total Existing Supplies** | **104,500** | **147,900** | **142,654** | **114,611** |
| **Planned Water Supplies (through 2020)** | | | | |
| ***Local Supplies*** | | | | |
| Restored Impacted Wells | -- | -- | 10,000 | 10,000 |
| New Saugus Wells | 0 | 0 | 10,000 | -- |
| Recycled Water | 15,300 | 15,300 | 15,300 | 15,300 |
| ***Imported Supplies*** | | | | |
| Draw From Long-Term Water Banking Programs | 0 | 0 | 40,000 | 13,000 |
| **Total Planned Supplies** | **15,300** | **15,300** | **75,300** | **38,300** |
| **Total Existing and Planning Supplies Through 2020 (not including Short-Term Semitropic Bank After 2013)** | **119,800** | **163,200** | **167,084** | **135,961** |

[a] *Since the 2000 UWMP was adopted, DWR released its SWP Delivery Reliability Report (May 2003), which analyzes the reliability of SWP supplies. During infrequent dry periods, deliveries are projected to be less than 50 percent, and possibly as low as 19 percent during an unusual single dry year condition that occurs about once every 70 years. During very wet years, full deliveries can be expected. Thus, the amount of water available to CLWA in the worst-case single dry year would be 19 percent of 95,200 af, or 18,088 af. In a worst-case multiple dry-year period, the amount of water available to CLWA in each of those dry years would be 37 percent of 95,200 af, or 35,244 af. The May 2003 DWR report also assumes average year SWP deliveries of 76 percent. This would result in 72,352 af of CLWA's Table A entitlement. The 2005 UWMP will reflect this new information.*

*For the 2000 UWMP, water supplies reflected in this table are based on SWP reliability as of 2000. Use of the 2003 SWP reliability figures would reduce the existing Single Dry Year and Consecutive Dry Year Table A amounts to 18,088 af and 35,244 af, respectively. The corresponding total existing supplies would be reduced to 122,842 af and 111,955 af, respectively. Total existing and planned supplies in Single Dry and Consecutive Dry Years would be reduced to 147,272 af and 133,305 af, respectively. Assuming 76 percent reliability in the average year, total existing supplies would be 120,052 af and total existing and planned supplies would be 135,352 af.*

*Source: Castaic Lake Water Agency, Santa Clarita Water Division, SB 610 Water Supply Assessment for The Keystone Project, March 2005.*

*Proposed Project Water Demand*

The Proposed Project's estimated potable water demand is based on water demand factors that have been provided by the CLWA in the Water Supply Assessment. Table V.N.1-7 summarizes the water demand that would be generated with the Proposed Project.

**Table V.N.1-7**
**Proposed Project Water Demand**

| Land Use | Size | Annual Rate | Water Demand (af per year) |
|---|---|---|---|
| Single-Family Residences | 96 units | 0.80 af / unit | 77 |
| Condominiums | 667 units | 0.24 af / unit | 160 |
| Apartments | 216 units | 0.23 af / unit | 50 |
| School | 21 acres | 3 af / acre | 63 |
| YMCA Facility[a] | 4 acres | 3 af / acre | 12 |
| Manufactured Slopes | 86 acres | 3 af / acre | 258 |
| Water Feature[b] | 16 feet high | N/A | N/A |
| ***Total*** | -- | -- | ***620*** |

*Note:*
*af = acre-feet*

[a] *The proposed YMCA Facility is categorized as "Parks" in Table 1 of the Water Supply Assessment.*
[b] *The water feature would be supplied with 2,500 gallons of water when it is first constructed. Then, the water would be re-circulated through a looped water system.*

*Source: Castaic Lake Water Agency Santa Clarita Water Division, SB 610 Water Supply Assessment for The Keystone Project, March 2005, page 5; and Christopher A. Joseph & Associates, 2005.*

As shown in Table V.N.1-7, the Proposed Project would generate a demand for approximately 620 acre-feet of water per year. This water would be delivered to the Proposed Project by a system of water lines that would be installed within the proposed roadways.

*Existing Conditions Plus Project Water Demand*

As shown in Tables V.N.1-2, V.N.1-3, and V.N.1-4, the existing water demand in the Santa Clarita Valley is approximately 81,700 acre-feet per year. When combined with the Proposed Project's demand of 620 acre-feet per year, the total water demand in the Santa Clarita Valley would be approximately 82,320 acre-feet per year.





According to the Water Supply Assessment for the Proposed Project, the project's estimated water demand (as indicated in Table V.N.1-7) was accounted for in the 2000 UWMP, as amended. The Water Supply Assessment states the following:[28]

> *The timing of the project places it within the timeframe for calculating 'planned future uses' within the 2020 water supply projection included in the 2000 UWMP.... The 2000 UWMP assumes an average growth rate of 2,240 connections per year based on the average growth rate that occurred during the 1990s. The Keystone project would add approximately 331 residential connections, which is less than the annual average anticipated by the 2000 UWMP and is, therefore, considered to be accounted for in this plan.*

The Water Supply Assessment for the Proposed Project concluded that "there will be sufficient water supply available when The Keystone project is ready for occupancy, in addition to existing and other planned future uses."[29] Therefore, it is anticipated that the future water supplies will meet the demand of the Proposed Project in addition to the existing demand and the associated impact would be less than significant. Nonetheless, mitigation measures are recommended below to further reduce the Proposed Project's less-than-significant impact on water supplies and to support the water conservation efforts of the CLWA.

*Fire Flow*

With respect to fire flow requirements, the County of Los Angeles Fire Department has indicated that the Proposed Project would require the following:[30]

- High Density Residential – up to 5,000 gallons per minute at 20 pounds per square inch residual pressure for up to five hours duration;
- Single-Family Detached Residential – 1,250 gallons per minute at 20 pounds per square inch residual pressure for a two-hour duration;

[28] *Castaic Lake Water Agency, Santa Clarita Water Division, SB 610 Water Supply Assessment for The Keystone Project, March 2005, page 3.*

[29] *Ibid., page 4.*

[30] *Written correspondence from David R. Leininger, Chief, Forestry Division Prevention Bureau, County of Los Angeles Fire Department, October 7, 2004 and December 17, 2004.*

- Two-family dwelling units (duplexes) – 1,500 gallons per minute at 20 pounds per square inch residual pressure for a two-hour duration;
- Five or more units with a single driveway access – 1,500 gallons per minute at 20 pounds per square inch residual pressure for a two-hour duration; and
- Institutional – 8,000 gallons per minute at 20 pounds per square inch residual pressure for up to four hours duration.

The actual fire flow requirements would be confirmed for each proposed land use by the County of Los Angeles Fire Department prior to Final Tract Map approval. As further discussed in Section V.M.2, Fire Protection, the final fire flow requirements for the Proposed Project would be based on the size of the buildings, their relationship to other structures, property lines, and types of building materials used. The associated water infrastructure would also be required to meet commercial and residential fire flow requirements as determined by the SCWD and the County of Los Angeles Fire Department. Therefore, the impact of the Proposed Project on fire flows would be less than significant (see also Section V.M.2, Fire Protection).

**Water Facilities**

The Proposed Project would be connected to existing water lines in Ermine Street (12-inch line) to the east, Golden Valley Road (16-inch line) to the north (under construction), and Newhall Ranch Road to the south. As indicated by the SCWD, no major increases in existing water distribution infrastructure or capacity enhancing alterations would be required in the general vicinity of the Proposed Project.[31]

Furthermore, as discussed above, the number of water connections that would be added to the existing water supply system in the Santa Clarita Valley is within the growth projections in the 2000 UWMP, as amended. As discussed in the Water Supply Assessment for the Proposed Project, the 2000 UWMP assumed an average growth rate of 2,240 connections per year based on the average growth rate that occurred during the 1990s. The Proposed Project would add approximately 331 residential connections, which is less than the annual average anticipated by the 2000 UWMP and is, therefore, considered to be accounted for in the 2000 UWMP, as amended.

With respect to onsite water facilities and infrastructure, the Proposed Project would likely include an approximately 14-inch water main that would loop throughout the project site and connect to smaller water lines that range in size from approximately eight to 10 inches. These proposed onsite water lines are illustrated in Figure V.N.1-3.

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[31] *Written correspondence W.J. Manetta, Jr., Retail Manager, Santa Clarita Water District, November 2, 2004.*



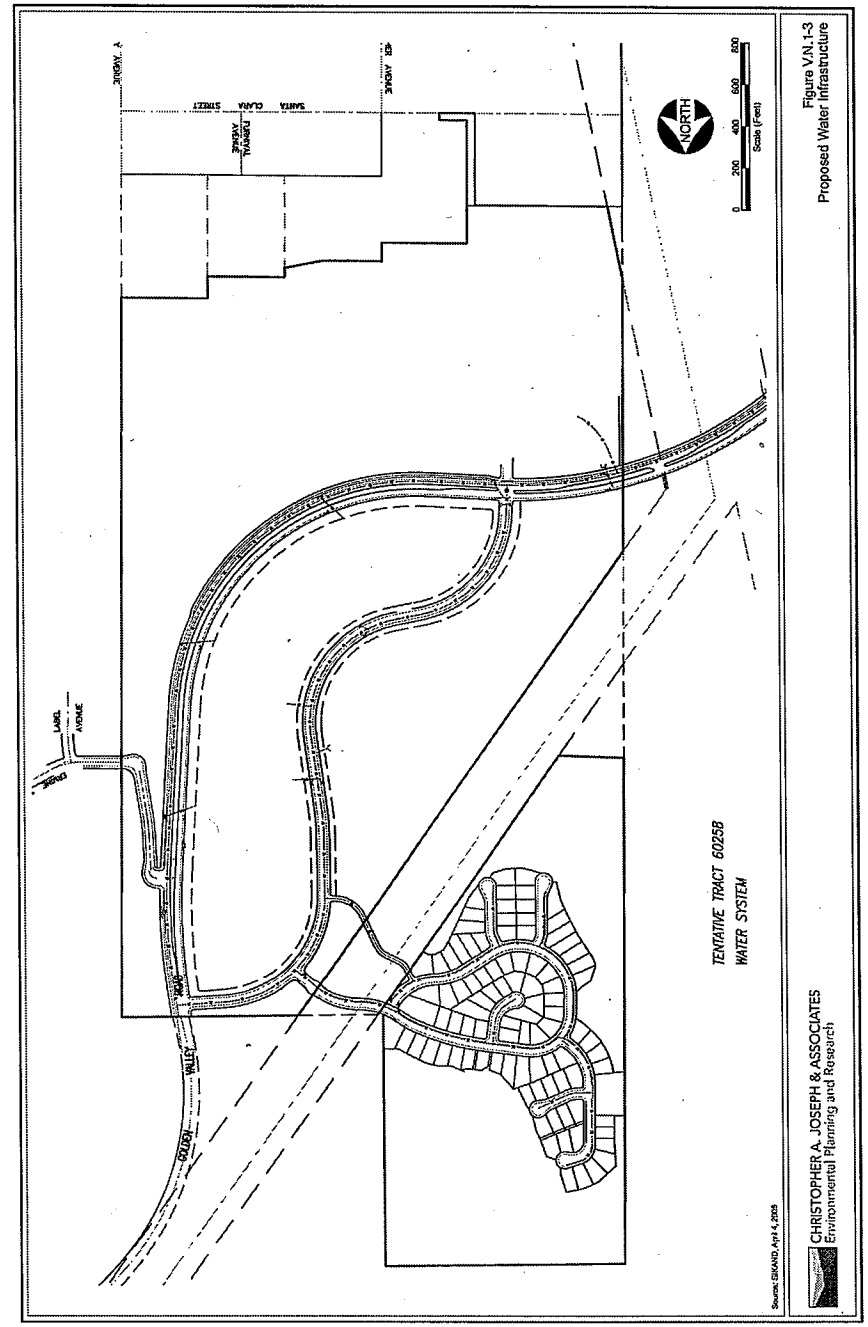


Figure V.N.1-3
Proposed Water Infrastructure

With respect to water treatment facilities, it is anticipated that the expanded Earl Schmidt Filtration Plant, which will be completed prior to the development of the Proposed Project, and the Rio Vista Filtration Plant will be able to accommodate the water treatment demand of the Proposed Project. As discussed above and in the Water Supply Assessment for the Proposed Project, the water demand associated with the Proposed Project was anticipated in the 2000 UWMP, as amended. As such, the CLWA's water treatment requirements associated with the water supply projections in the 2000 UWMP, as amended, can be accommodated by the Earl Schmidt Filtration Plant and the Rio Vista Filtration Plant.

Overall, the impacts of the Proposed Project on water facilities and water treatment facilities are anticipated to be less than significant.

## CUMULATIVE IMPACTS

To analyze cumulative impacts, a list of related projects was compiled by the City of Santa Clarita (Traffic and Engineering Department and Planning and Economic Development Department) consisting of all approved, proposed or potential projects located within the City of Santa Clarita within an approximate two-mile radius of the project site. A two-mile radius is used as a standard for areas that are urbanizing in which projects are located within a relevant geographical area in proximity to the Proposed Project site using similar infrastructure (e.g., roadways, utilities) and public services. The following list was presented in Section III. Environmental Setting of this Draft EIR and is provided here for reference:

**List of Related Projects**

| Map No. | Project Name | Project Location | Description |
|---|---|---|---|
| 1 | HH Seco II LLC Master Case 01-317 | Southwest corner of Seco Cyn Rd and Copper Hill Dr | Development for a new 40,000 square foot commercial shopping center |
| 2 | Rice Development Master Case 02-231 | Southwest corner of Seco Cyn Rd and Copper Hill Dr | Development for an 84,000 square foot self-storage facility |
| 3 | TT 062322 | North of Soledad Cyn Rd, south of Santa Clara River, approx. 1 mi. east of Bouquet Cyn Rd | 420 townhomes |
| 4 | Riverpark | East of Bouquet Cyn Rd, north of Santa Clara River | 432 single-family DU, 657 multi-family DU, 16,000 square feet commercial |
| 5 | Aspen Investment Company Master Case 02-273 | North corner of Soledad Cyn Rd and Valley Center Dr | Development for 8 new industrial buildings totaling 109,000 square feet |
| 6 | Soledad Circle Estates | Soledad and Penlon Road | 150 residential units on 19.5 acres |
| 7 | TT 46018 (S&S) | East and west of Plum Cyn Rd, north of Whites Cyn Rd | 1,298 single-family DU, 1,202 condominium units, 150,000 square |





**List of Related Projects**

| Map No. | Project Name | Project Location | Description |
|---|---|---|---|
| | | | feet commercial |
| 8 | TR 52763 (S&S) | West of Plum Cyn Rd, north of Whites Cyn Rd | 11 single-family DU |
| 9 | Plum Canyon TR 31803 | North and south of Golden Valley Rd, west of Plum Cyn Rd | 498 single-family DU |
| 10 | Rodgers Development Master Case 02-232 | Northeast corner of Bouquet Cyn Rd and Plum Cyn Rd | Development for a new 34,000 square foot commercial shopping center |
| 11 | TT 98046 | North of Copper Hill Dr at terminus of Benz Rd | 91 single-family DU |
| 12 | TT 47760 | Copper Hill Dr at Haskell Cyn Rd | 480 single-family DU |

The Water Supply Assessment for the Proposed Project included an analysis of the water demand of all planned future uses in combination with the Proposed Project. The conclusions of the Water Supply Assessment with respect to planned future uses are discussed below in addition to the list of 12 related projects (see Related Projects list above).

**Water Supplies**

Implementation of the Proposed Project in combination with the 12 related projects would generate a demand for approximately 2,307 af per year of water, further increasing the demand for water in the Santa Clarita Valley (see Table V.N.1-8). However, the CLWA anticipates that its projected water supplies available during normal, single-dry, and multiple-dry water years, as included in its 2000 UWMP, as amended, would meet the projected water demand associated with the Proposed Project, in addition to the existing and other planned future uses in the CLWA's system.

Furthermore, as discussed above, a Water Supply Assessment was prepared by the CLWA for the Proposed Project (see Appendix 10 to this Draft EIR). Pursuant to Section 10910(c)(4) of the State Water Code, the Water Supply Assessment included a discussion of whether the water supply projections can meet the water demand associated with the Proposed Project, in addition to existing and planned future uses, including agricultural and manufacturing uses. As discussed above, the Water Supply Assessment for the Proposed Project included the Proposed Project and "planned future uses", which includes probable future projects.[32] The Water Supply Assessment clarifies "planned future

[32] *Castaic Lake Water Agency, Santa Clarita Water Division, SB 610 Water Supply Assessment for The Keystone Project, March 2005.*

uses" as within the projections included in the 2000 UWMP, as amended.[33] Therefore, the Proposed Project and related projects would not be cumulatively considerable, and impacts on water supplies would be less than significant.

**Table V.N.1-8**
**Projected Water Consumption for Proposed and Related Projects**

| No. | Land Use | Size | Daily Consumption Rate[a] (gpd) | Daily Water Consumption (gpd) | Annual Water Consumption (af) |
|---|---|---|---|---|---|
| 1 | HH Seco II - Commercial Retail | 40,000 sq.ft. | 180 gpd/1,000 sq.ft. | 7,200 | 8 |
| 2 | Rice Dev – Self Storage | 84, 000 sq.ft. | 30 gpd/1,000 sq.ft. | 2,520 | 3 |
| 3 | TT 062322 –Townhomes | 420 du | 234 gpd/du | 98,280 | 110 |
| 4 | Riverpark – Single-Family | 432 du | 312 gpd/du | 134,784 | 151 |
| | Multi Family | 657 du | 234 gpd/du | 153,738 | 172 |
| | Commercial Retail | 16,000 sq.ft. | 180 gpd/1,000 sq.ft. | 2,880 | 3 |
| 5 | Aspen Investment - Industrial | 109, 000 sq.ft. | 30 gpd/1,000 sq.ft. | 3,270 | 4 |
| 6 | Soledad Circle – Single-Family | 150 du | 312 gpd/du | 46,800 | 52 |
| 7 | TT 46018 – Single-Family | 1,298 du | 312 gpd/du | 404,976 | 454 |
| | Multi Family | 1,202 du | 312 gpd/du | 281,268 | 315 |
| | Commercial Retail | 150,000 sq.ft. | 180 gpd/1,000 sq.ft. | 27,000 | 30 |
| 8 | TR 52763 – Single-Family | 11 du | 312 gpd/du | 3,432 | 4 |
| 9 | Plum Canyon – Single-Family | 498 du | 312 gpd/du | 155,376 | 174 |
| 10 | Rodgers Dev - Commercial Retail | 34,000 sq.ft. | 180 gpd/1,000 sq.ft. | 6,120 | 7 |
| 11 | TT 98046 – Single-Family | 91 du | 312 gpd/du | 28,392 | 32 |
| 12 | TT 47760 – Single-Family | 480 du | 312 gpd/du | 149,760 | 168 |
| | | | *Related Projects Total* | | *1,687* |
| | | | *Proposed Project Total* | | *620* |
| | | | *Cumulative Total* | | *2,307* |

[33] *Castaic Lake Water Agency, Groundwater Perchlorate Contamination Amendment and Other Amendments, 2000 Urban Water Management Plan, January 2005.*





**Table V.N.1-8**
**Projected Water Consumption for Proposed and Related Projects**

| No. | Land Use | Size | Daily Consumption Rate[a] (gpd) | Daily Water Consumption (gpd) | Annual Water Consumption (af) |
|---|---|---|---|---|---|

*Notes: af = acre-feet; sq.ft. = square feet; gpd – gallons per day*

[a] *Water Consumption rates are 120 percent of wastewater generation rates.*

**Water Facilities**

As discussed in the Water Supply Assessment for the Proposed Project, the 2000 UWMP assumed an average growth rate of 2,240 water connections per year based on the average growth rate that occurred during the 1990s. The Proposed Project would add approximately 331 residential connections, which is less than the annual average anticipated by the 2000 UWMP. Therefore, the effect of the additional water connections due to the Proposed Project would not incrementally contribute a considerable amount to the cumulative total number of connections. As such, the associated cumulative impact would not be cumulatively considerable and impacts would be less than significant.

With respect to water treatment facilities, it is anticipated that the expanded Earl Schmidt Filtration Plant and the Rio Vista Filtration Plant will be able to accommodate the water treatment demand of the Proposed Project and the related projects.

In addition, the potential need for the related projects to upgrade water lines to accommodate their water needs is site-specific and there is little, if any, cumulative relationship between the development of the Proposed Project and the related projects. Therefore, no cumulative water infrastructure impact or water treatment facilities impact are anticipated from the development of the Proposed Project and the related projects. Thus, the Proposed Project's incremental increase is not considerable and the impacts would be less than significant.

## MITIGATION MEASURES

### Project Mitigation Measures

Although the Proposed Project would not have a significant impact on water supply the following mitigation measures are recommended to reduce further the Proposed Project's impacts associated with water supplies:

**N.1-1** The project developer shall ensure that the landscape irrigation system be designed, installed and tested to provide uniform irrigation coverage. Sprinkler head patterns shall be adjusted to minimize over spray onto walkways and streets.

**N.1-2** The project developer shall install either a "smart sprinkler" system to provide irrigation for the landscaped areas or, at a minimum, set automatic irrigation timers to water landscaping during early morning or late evening hours to reduce water losses from evaporation. Irrigation run times for all zones shall be adjusted seasonally, reducing water times and frequency in the cooler months (fall, winter, spring). Sprinkler timer run times shall be adjusted to avoid water runoff, especially when irrigating sloped property.

**N.1-3** The project developer shall select and use drought-tolerant, low-water consuming plant varieties to reduce irrigation water consumption.

**N.1-4** The project developer shall install ultra-low flush water toilets and water-saving showerheads in new construction. Low-flow faucet aerators should be installed on all sink faucets.

### Cumulative Mitigation Measures

No cumulative mitigation measures are required.

## LEVEL OF SIGNIFICANCE AFTER MITIGATION

### Project

The Proposed Project's impacts on water supply would be less than significant without mitigation. However, the implementation of the recommended mitigation measures N.1-1 through N.1-4 provide measures to reduce wasteful consumption of water resources and, thus, would further reduce the Proposed Project's impacts.





### Cumulative

The Water Supply Assessment for the Proposed Project included the Proposed Project and "planned future uses", which includes probable future projects. The Assessment clarified "planned future uses" as within the projections included in the 2000 UWMP. Therefore, no cumulative impacts to water supply is expected and impacts would be less than significant. No cumulative water infrastructure impact or water treatment facilities impact are anticipated from the development of the Proposed Project and the related projects and thus no mitigation is required and cumulative impacts would be less than significant.

Pages omitted.

Visit http://www.santa-clarita.com/cityhall/cd/planning/eir/completed.asp for complete document.

Attachment 23-F

DRAFT

Environmental Impact Report

California State Clearinghouse No. 1998041127

# Castaic Lake Water Agency

Supplemental Water Project Transfer of 41,000 Acre-Feet of State Water Project Table A Amount

CASTAIC LAKE WATER AGENCY

June 2004

Pages omitted.

# PREFACE

This Environmental Impact Report (EIR) evaluates the potential environmental impacts of the transfer of an existing 41,000 acre-feet (AF) of State Water Project (SWP) Table A Amount[1] from a SWP contractor (the Kern County Water Agency [KCWA]) and its member unit in Kern County (the Wheeler Ridge-Maricopa Water Storage District [WRMWSD]), to the Castaic Lake Water Agency (CLWA), another SWP contractor located in Los Angeles and Ventura counties. This EIR also evaluates the use of SWP facilities from northern California to Los Angeles County for the delivery of SWP water to the CLWA service area, and use of this water within the CLWA service area. These actions are referred to as "the Project" in subsequent sections of this EIR.

The Project is intended to meet water demands of existing users and a portion of future water demand from anticipated growth within the CLWA service area. CLWA is not a land use agency and has no control over where and when growth will occur within its service area. To the extent that land use decision-makers utilize or rely on this EIR to predict future CLWA water supplies, they are cautioned that although CLWA will implement all feasible measures to firm up its water supplies (and CLWA's retail purveyors may implement conjunctive use programs using SWP and groundwater supplies to increase the reliability of deliveries to their customers), past water deliveries are not a guarantee of future delivery rates. Rather than repeat this advice to decision-makers in each section of the EIR, the reader is requested to keep this advice in mind when reading the information about the availability and reliability of water supplies wherever such information appears. Information regarding water supplies is presented throughout this document as it relates to the CLWA service area (section 1.3.1), the Project description (section 2.3), the environmental setting (section 3.0), and growth-inducing effects and growth-related impacts (Chapter 4). To facilitate your reading of this EIR, it is suggested that the reader refer to section 10.0, "List of Acronyms and Glossary of Terms." The acronyms used in this EIR are defined the first time they are used in the text.

The transfer of SWP Table A Amount that is the subject of the present EIR was contractually completed in 1999, and imported water supply associated with the transfer became available for use by CLWA starting in January 2000 (refer to the discussion under Related Environmental Documentation for additional detail).

CLWA is the lead agency for preparation of the EIR and thus will evaluate, and if appropriate, certify this EIR, make CEQA findings, and approve the Project. CLWA has the principal responsibility for carrying out and implementing the Project because 1) a substantial portion of

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1 "Table A" is a term used in SWP Water Supply Contracts. The "Table A Amount" is the annual maximum amount of water to which an SWP Contractor has a contract right to request delivery, and is specified in Table A of each Contractor's Water Supply Contract. (Prior to the Settlement Agreement arising out of a legal challenge to the Monterey Amendment to the State Water Project contracts, the Table A Amount was referred to as "entitlement.") The amount of water actually available for delivery in any year may be an amount less than the Contractor's Table A Amount due to a number of factors, including hydrologic conditions. The parallel term used in the member unit contract between KCWA and WRMWSD is "Contract Entitlement" (sometimes referred to as "Table 1 Entitlement"). For the sake of brevity, in this EIR the term "Table A Amount" refers to the Table A Amount in the SWP Water Supply Contracts, or "Annual Entitlement" prior to the Monterey Amendment; where the term is used in connection with WRMWSD, it refers to the Table 1 Entitlement under its member unit contract with KCWA.

the Project occurs within CLWA's jurisdiction and substantially affects CLWA; 2) CLWA has been the lead proponent of the Project and has assumed the primary task of effectuating the SWP water supply contract amendment; 3) CLWA has the expertise to implement the Project; and 4) the Project, although requiring the use of SWP facilities, would involve transfers only between three agencies (CLWA, KCWA, and WRMWSD) within a limited geographic area and does not implicate the entire statewide water rights or supply framework.

The California Department of Water Resources (DWR), KCWA, and WRMWSD are considered to be responsible agencies. Responsible agencies are public agencies other than the lead agency that have responsibility for carrying out or approving a project (CEQA Guidelines section 15381).

# EXECUTIVE SUMMARY

## PROJECT DESCRIPTION

### Project Location

The Project would use existing SWP facilities located between the southern Delta facilities and Castaic Lake; these facilities include the SWP's southern Delta facilities (Clifton Court Forebay, the Banks Pumping Plant, and Bethany Reservoir); the San Luis Reservoir facilities (San Luis Reservoir, O'Neil Forebay, and the Gianelli Pumping-Generating Plant); and the California Aqueduct from the southern Delta to Castaic Lake, including pumping plants, a power plant, and storage facilities along the Aqueduct (Buena Vista, Teerink, Chrisman, Edmonston, and Oso pumping plants, Warne power plant, and Quail, Pyramid and Castaic lakes). These facilities are located in Alameda, Contra Costa, Fresno, Kern, Kings, Los Angeles, Merced, San Joaquin, and Stanislaus counties. The Project also could affect environmental resources located in the CLWA and WRMWSD service areas. The CLWA service area is located in northern Los Angeles and eastern Ventura counties. The WRMWSD is located in the southern extent of the San Joaquin Valley in Kern County.

### Project Objectives

The portion of the CLWA service area that is located within the unincorporated and incorporated portions of Los Angeles County is experiencing substantial growth in population and urbanization. This trend is expected to continue based on development that already has been approved by the County of Los Angeles and the City of Santa Clarita and development that is projected in local adopted plans. (Considerably less growth is occurring in or is anticipated to occur in the portion of the service area that is in Ventura County since this area is designated for agricultural or open space uses in the general plan, and the Ventura County Save Open-Space and Agricultural Resources [SOAR] Initiative requires a vote of the people for most changes to the general plan policies and land use designations regarding open space, agricultural, and rural lands.) Pursuant to the provisions of its SWP Water Supply Contract, CLWA has over time acquired a right to delivery of SWP water at an amount necessary to reasonably supply the Agency's increasing demand. The Project is an action by CLWA to maintain the water supply needed to meet water demands of existing users and a portion of future water demand from anticipated growth within the CLWA service area.

Specific Project objectives are as follows:

- Augment CLWA's SWP Table A Amount to meet water demands of existing users and some future anticipated growth.
- Provide a means of delivery for the augmented water supplies.

### Description of the Project

The Project is the transfer of an existing 41,000 AF of SWP Table A Amount from KCWA and its member unit in Kern County, WRMWSD, to CLWA. The Project also includes the use of SWP

facilities from northern California to Los Angeles County for the delivery of SWP water to the CLWA service area, and use of this water within the CLWA service area. The Project water is transported from certain points of origin in the SWP system to the CLWA intake south of Castaic Lake via existing SWP facilities. The points of origin and delivery are identified in the 41,000 AF Transfer Agreement and the Point of Delivery Agreement. These and other documents referenced in this EIR are available for public inspection at the CLWA offices at 27234 Bouquet Canyon Road, Santa Clarita, CA 91350, (661) 297-1600.

The Project currently is being implemented by an amendment to the SWP water supply contracts of CLWA and KCWA executed in 1999. The Project is to authorize CLWA to use water delivered from the 41,000 AF of SWP Table A Amount for water demands of existing users and a portion of future water demand from anticipated growth within the CLWA service area. As described in detail in section 3.15 and Appendix D, the annual allocations of SWP water made by DWR are based on that year's hydrologic conditions, the amount of water in storage in the SWP system, and Contractors' requests for SWP supplies. Thus, the actual amount of water available for delivery to CLWA as a result of the 41,000 AF transfer would vary from year to year. (Section 3-0 outlines the assumptions used in the environmental impact analysis regarding the amount of water that would be delivered for use by CLWA.) Water would be requested by CLWA as needed to meet the demands of its service area, and as discussed in section 1.3.1, the transfer of Table A Amount would be one of a number of projects implemented by CLWA (e.g., infrastructure improvements, groundwater banking programs, increased recycling and conservation, and expanded use of local groundwater sources) to increase water reliability. Those projects that are considered reasonably foreseeable and for which sufficient information is available are included in the cumulative impacts analysis contained in section 6.3.3.1 of this EIR.

The Project does not include the construction of any additional SWP facilities or new facilities in the CLWA, KCWA, or WRMWSD service areas.

### Permits and Other Approvals to Implement the Project

The amendment to the SWP water supply contract was approved by CLWA and DWR in 1999. Associated amendments to water supply and delivery contracts have been approved by KCWA and WRMWSD. WRMWSD is the KCWA member unit providing this Table A Amount. No permits or other approvals would be required other than the certification of this EIR.

## RELATED ENVIRONMENTAL DOCUMENTATION

### Supplemental Water Project EIR

The transfer of 41,000 AF of SWP Table A Amount between CLWA, KCWA, and WRMWSD (41,000 AF Transfer Agreement) and the Point of Delivery Agreement between DWR, KCWA, and CLWA were evaluated previously in the Supplemental Water Project Final EIR (CLWA 1999).

The Second Appellate Court, Fourth Division and the Superior Court of Los Angeles ordered that this EIR be decertified in January 2002 (*Friends of the Santa Clara River v. Castaic Lake Water Agency* (2002) 95 Cal. App. 3d 1373 [*Friends*]) because it tiered from the Monterey Agreement Program EIR, which was itself decertified as a result of an appellate court decision issued while

*Friends* was on appeal. "All other contentions" concerning the legal adequacy of the Supplemental Water Project EIR were found to be "without merit." The Court of Appeal specifically ordered the Trial Court to "issue a writ of mandate vacating the certification of the EIR," and to "retain jurisdiction until [CLWA] certifies an EIR complying with CEQA," and "consider such orders it deems appropriate under section 21168.9 [of the Public Resources Code]." The CLWA Board of Directors decertified CLWA's Supplemental Water Project Final EIR on November 27, 2002.

In September 2002, the Trial Court was requested to prohibit CLWA from using the 41,000 AF in any manner. Trial Court refused to enjoin the performance of the 41,000 AF Transfer Agreement, maintained its jurisdiction over the matter, and authorized CLWA to utilize "any of the 41,000 AFY [acre-feet per year]," albeit, with certain limitations:

> Respondent [CLWA] will not be prohibited from using the water to which it is entitled, but petitioner may renew its application for such prohibition based upon evidence of the actual use of such additional water for purposes it considers improper.

The above Order was issued without prejudice to a renewed request by the Petitioner for an injunction on all portions of CLWA's project pending completion of the EIR[1]. The present EIR is being prepared in accordance with the decisions of the Second Appellate Court, Fourth Division and the Superior Court of Los Angeles (Superior Court Case No. BS05694).

KCWA, WRMWSD, CLWA, and DWR previously approved the various contract amendments on the basis of the 1999 Supplemental Water Project Final EIR and other environmental analyses and documentation.

**Monterey Amendment Program EIR**

During the 1990s, disagreements arose between DWR, Agricultural Contractors, and municipal and industrial (M&I) Contractors about how available SWP supplies should be allocated. The SWP Contractors and DWR agreed to negotiate a settlement of their differences and develop a new approach to managing SWP resources through a major overhaul of the Water Supply Contracts. After a series of exhaustive negotiating sessions, an agreement was reached in December 1994 in Monterey, California on a set of principles, known as the "Monterey Agreement." The Monterey Agreement principles were implemented through an amendment to the Water Supply Contracts between DWR and the SWP Contractors, which became known as the "Monterey Amendment." The term "Monterey Amendment" is used in subsequent sections of this EIR. The Monterey Amendment was approved in 1995 and went into effect in August 1996.

A Program EIR analyzing the environmental impacts of the Monterey Amendment (Monterey Agreement EIR) was prepared and certified by the Central Coast Water Authority (CCWA) in 1995. In late 1995, a lawsuit was filed by the Planning and Conservation League (PCL), Plumas County Water Conservation and Flood Control District (Plumas County), and Citizens

1 Petitioners appealed the Remand Order issued by the Superior Court in this case. The Court of Appeal affirmed the Trial Court's order (refusing the request for an injunction) on December 1, 2003.

Planning Association of Santa Barbara County (CPA) (collectively referred to as the "plaintiffs") challenging the EIR. The plaintiffs argued that the environmental impact analysis prepared was inadequate because CCWA was not a proper lead agency and the EIR analysis did not reflect the inability of the SWP to deliver full Contract amounts to Contractors, even though they held contractual "entitlements" to those supplies. In 2000, the California State Court of Appeal (Third District) found that a new EIR must be prepared. That litigation is referred to as the PCL Litigation in this EIR.[2]

Discussions to mediate a settlement began in 2001 and were finalized in May 2003.[3] All parties to the litigation have signed the Settlement Agreement. The Settlement Agreement calls for DWR to prepare a new EIR pursuant to CEQA (a Notice of Preparation [NOP] was issued by DWR on January 24, 2003),[4] while the Monterey Amendment's provisions remain in operation. Pursuant to the Settlement Agreement, the parties are now administering the preparation of a new EIR, which is expected to be completed in approximately two years. The new EIR will evaluate the potential environmental impacts of changes to SWP operations incorporated in the Monterey Amendment and the Settlement Agreement. The Settlement Agreement also calls for DWR to produce a biennial SWP Delivery Reliability Report. The SWP Delivery Reliability Report - 2002 was issued in May 2003 (DWR 2003b). The Settlement Agreement did not change the substance of the Monterey Amendment, but addressed the process by which the new Monterey Amendment EIR will be prepared.

It should be noted at this point that the Settlement Agreement concerning the PCL Litigation creates a specific exclusion for this Project from any prohibitions against transfers of State Water Project Table A Amounts by the Settlement Agreement. The exclusion states:

> With respect to Section III(c)(4)(b) regarding the Kern-Castaic Transfer, the Parties recognize that such water transfer is subject to pending litigation in the Los Angeles County Superior Court following remand from the Second District Court of Appeal (See Friends of the Santa Clara River v. Castaic Lake Water Agency 95 Cal.App.4th 1373, 116 Cal.Rptr.2d 54 (2002); review denied, April 17, 2002). The Parties agree that jurisdiction with respect to that litigation should remain in that court and that nothing in this Settlement Agreement is intended to predispose the remedies or other actions that may occur in that pending litigation.

The order on remand from the appellate court in the Friend case specifically ordered the Trial Court "to retain jurisdiction until [CLWA] certifies an EIR complying with CEQA" and "consider such orders it deems appropriate under section 21168.9 [of the Public Resources Code]." This EIR thus remains under the jurisdiction of the Superior Court until the EIR is certified by CLWA.

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2 *Planning and Conservation League, et al. v. Department of Water Resources* (2000) 83 Cal. App. 4th 892.

3 In May 2003, the settlement agreement among the plaintiffs, DWR, and the SWP Contractors (referred to herein as the "Settlement Agreement") was executed and approved by the State Attorney General's office. On May 20, 2003 the Settlement Agreement was approved by the Sacramento Superior Court.

4 The NOP is entitled Notice of Preparation of Environmental Impact Report for the Monterey Amendment to the State Water Project Contracts (Including Kern Water Bank Transfer) and Other Contract Amendments and Associated Actions as part of a Proposed Settlement Agreement in Planning and Conservation League v. Department of Water Resources.

**Capital Program and Water Plan, including Acquisition of Supplemental Water and of a Proposed Second Plant Site, EIR**

In 1988, CLWA completed the Capital Program and Water Plan, including Acquisition of Supplemental Water and of a Proposed Second Plant Site, Final EIR (Capital Program EIR) (CLWA 1988), which evaluated the potential environmental impacts of the proposed Capital Improvements Program, including the acquisition of supplemental water, and the construction of a new treatment plant and facilities improvements. The Capital Program EIR evaluated a proposal for CLWA to obtain additional SWP Table A Amount of up to 37,800 AF to supplement the 1988 SWP Table A Amount of 41,500 AF. This EIR assumed that deliveries from the new SWP Table A Amount would become 100 percent reliable before 2010. It also identified a total water demand of 120,000 AFY to support a population of 270,000 persons in the year 2010. The implementation of reasonable conservation measures and recycling was projected to reduce net demand to 106,300 AFY, an approximately 11 percent reduction. The Project evaluated in the present EIR was programmatically evaluated in the Capital Program EIR (CLWA 1988).

## ENVIRONMENTAL SETTING

CEQA Guidelines section 15125 directs that an EIR must include a description of the physical environmental conditions in the vicinity of the Project as they exist at the time the NOP is published. This environmental setting will normally constitute the baseline physical conditions by which the lead agency determines whether an impact is significant. This Project was previously analyzed in the 1999 Supplemental Water Project Final EIR (CLWA 1999); the 41,000 AF Transfer Agreements were duly executed, and the Project was implemented. Solely relying on the description of physical conditions that existed at the time that the NOP for the present EIR was published (January 2003) would fail to capture any changes to the pre-Project conditions that may have resulted from the ongoing implementation of the 41,000 AF Transfer Agreement. Thus, this EIR's description of the Project's environmental setting includes information from the general timeframe when the January 2003 NOP was issued (referred to as current or present conditions), as well as information describing the environmental setting as it existed when the NOP for the 1999 Supplemental Water Project Final EIR was published (April 1998).

## SUMMARY OF SIGNIFICANT IMPACTS AND MITIGATION MEASURES

Table ES-1 summarizes the direct and indirect impacts of the Project, mitigation measures for significant impacts, and the residual impacts that would occur after the implementation of mitigation measures. No significant direct impacts would occur in any of the three geographic areas evaluated. Very minor, less than significant impacts to aesthetic/visual resources, cultural resources, and geology and soils would occur at San Luis Reservoir due to the slight seasonal change in the timing of water delivered from the reservoir. Imperceptible or very minor, less than significant impacts to water quality in the Delta could result in some years due to a minor change in the timing of Delta diversions. However, these changes would fall well within the range of historical and future anticipated SWP diversions from the Delta. Other changes associated with the SWP are less than significant impacts from increased electrical power demand and air emissions from the generation of electrical power to move water from WRMWSD to the CLWA service area.

The only impact to WRMWSD is a less than significant impact to groundwater quality from the minor reduction of SWP Table A supply that has been replaced by other water management actions. Under some extreme conditions this could result in increased reliance on other water sources and groundwater. Increased use of other water and groundwater would result in higher TDS water used and recharged to local groundwater.

The additional water supply provided by the Project would remove an obstacle to growth, and significant, indirect, growth-related impacts to all environmental resources could result from Project implementation. Compliance with the adopted plans and policies of local jurisdictions would reduce all of these impacts to less than significant, with the possible exception of five resources: aesthetics, air quality, biological resources, transportation/traffic, and utilities/service systems (solid waste disposal). Specific mechanisms for implementing these policies would be determined in the course of project-specific environmental review, as required under CEQA.

## CUMULATIVE IMPACTS

No significant cumulative impacts resulting from the Project were identified for the SWP and associated facilities or the WRMWSD. Significant cumulative Project impacts in the CLWA service area would be as described under indirect impacts, and the same mitigation measures would apply. Impacts to aesthetics, air quality, biological resources, transportation/traffic, and utilities/service systems (solid waste disposal) could be unavoidable.

## ALTERNATIVES TO THE PROJECT

Five alternatives were carried forward for detailed analysis.

### Alternative 1, No Project Alternative

Under the No Project Alternative, CLWA would not acquire the additional Table A Amount or acquire the associated contractual rights for delivery of water associated with the transfer. The demand for high quality surface water is expected to increase throughout all of southern California as a result of continued growth, and local planning agency documents project continuing growth in the CLWA service area. The contract right to the Table A Amount that is the subject of the Project could be acquired and transferred to other portions of urbanized California. The amount, timing, and location of such a transfer are highly speculative, however, and this scenario is not considered further. Two hypothetical scenarios have been carried forward for detailed analysis that are intended to define a reasonable range of possible actions that could occur under this alternative. Actions relating to future land development are not under the control of CLWA, however, and could vary depending upon the actions of agencies with land use planning and permitting authority.

*Scenario 1 –Moratorium on New Development, Existing Users Subject to Delivery Cutbacks (Moratorium Scenario)*

In the absence of the Project, under this scenario, a moratorium on new development would be implemented. This assumes that the local retail water purveyors[5] within the CLWA service area decide that there is insufficient water to issue "will serve" letters to supply development and that local land use agencies respond by imposing a moratorium on new development in the CLWA service area.

Under this scenario, development that had already been approved or recorded but not yet built in the Santa Clarita Valley would not be built, nor would pending (unapproved) development. (Approved projects are subdivisions that have been granted an approved tentative tract map that is not yet recorded or has expired; recorded projects are subdivisions that have recorded a final tract map but are not yet built.) The 1998 DMS included 15,973 housing units (8,588 approved, 2,292 recorded, and 5,093 pending). The 2002 DMS included 33,113 housing units (13,586 approved, 9,915 recorded, and 9,612 pending). Assuming 3.1 persons per household, this amount of development would result in a population of approximately 49,510 persons, using the 1998 DMS, and 102,640 persons, using the 2002 DMS. In comparison, the Project could support approximately 35,600 housing units given an average year water supply, which would house approximately 106,700 persons. Thus, the amount of development and associated population that could be allowed under this scenario would be less than could occur under the Project.

Some additional groundwater production wells might be required to serve existing demand that would have been met by the 41,000 AF transfer. Treatment at the wellhead likely would be needed, depending upon local groundwater characteristics. New underground distribution pipelines also may be required. Electric pumps would be used as needed.

*Scenario 2 –Build-Out of Recorded and Approved Projects in DMS (Build-Out Scenario)*

Under the Build-Out Scenario, approved and recorded projects listed in the DMS for the Santa Clarita Valley would be developed, notwithstanding the potential shortfall in reliable water supply. Based on the DMS from both 1998 and 2002, the number of housing units in approved and recorded DMS projects considered under this scenario (10,880 and 23,500 units, respectively) is less than the number of housing units that could be supported by the Project given an average year water supply of 34,400 AF (35,600 units). The population associated with the development identified in the 1998 DMS would be about 33,730 persons; the population associated with the 2002 DMS development would be about 72,850 persons. In comparison, the population that could be served by the Project would be about 106,700 persons. Thus, the amount of development and associated population that could be allowed under this scenario would be less than could occur under the Project.

Under this scenario, existing demand currently met by the 41,000 AF transfer and the increased water demand from new development would rely on existing water supplies (principally local groundwater resources) that are currently not used for urban purposes. Treatment at the

5 The CLWA Act refers to "retail water distributors," although the term "retail water purveyors" also is commonly used. For purposes of this report, the terms are synonymous.

wellhead likely would be needed, depending upon local groundwater characteristics. New underground distribution pipelines also may be required. Electric pumps would be used as needed.

**Alternative 2, Increased Extractions from the Saugus Formation (Increased Groundwater Extractions)**

Under this alternative, in lieu of the Project, up to 41,000 AFY would be extracted from the Saugus Formation and delivered to users in the CLWA service area. The extraction would be accomplished by increased use of existing wells and by the installation of 15 additional wells, pumps, and wellhead treatment facilities. Existing or new distribution facilities such as pipelines and pumping stations would be used to transport this water to existing and planned treated water distribution facilities. Pumps and treatment facilities would use electrical power. Wherever possible, distribution facilities would be placed in public rights-of-way, including streets, utility, and railroad corridors. Disturbed areas would be restored to their former appearance once construction was completed. It is estimated that approximately 40 acres would be disturbed by the new facilities, which would be constructed and operated either by CLWA, individual purveyors, or other parties. A detailed geohydrologic investigation would be necessary prior to drilling on a site-by-site basis.

Until contaminant remediation is completed, existing, localized perchlorate contamination in a small part of the Saugus Formation would limit potential well locations. Field studies and groundwater modeling activities are in progress to evaluate how best to hydraulically contain the portion of the aquifer system where production wells have been shut down, while simultaneously preventing perchlorate movement to currently unimpacted areas. The field studies have included the installation and sampling of monitoring wells at multiple depths and locations on and around the Whittaker-Bermite site, the most likely source of perchlorate; water level monitoring in these wells; aquifer testing of two unimpacted water supply wells; and groundwater velocity testing in alluvial monitoring wells located between the site and the Santa Clara River. These studies have helped the water purveyors and the Whittaker Corporation further refine the current understanding of groundwater flow patterns in specific areas on and near the site (such as along the Holser Fault). This information has been incorporated into a regional groundwater flow model that has been developed by the purveyors and whose calibration and construction was recently reviewed and approved by the California Department of Toxic Substances Control (DTSC). The model is being used to identify a pumping scheme that would meet the objectives of restoring the lost water supply from the impacted wells (with wellhead treatment) while simultaneously containing perchlorate and hydraulically limiting its movement downgradient to unimpacted wells and other portions of the aquifer system where new water supply wells might be constructed. The modeling analysis accounts not only for the pumping of impacted wells, but also (a) the 2000 Urban Water Management Plan's (UWMP) pumping plan for unimpacted wells throughout the Santa Clarita Valley and (b) the significant year-to-year variation in local hydrology (especially groundwater recharge) that occurs in the Valley (CH2MHill 2004). The modeling simulations will be used to guide selection of a final pumping plan for the impacted Alluvial Aquifer well and the impacted Saugus Formation wells. The selection of a final pumping plan will be made jointly by the purveyors and the Whittaker Corporation, with regulatory oversight and permitting performed by the California Department of Health Services (CA DHS) with technical support from the DTSC.

There are numerous wells in the Saugus Formation, other than the wells that were voluntarily shut down due to perchlorate contamination. Additionally, other Saugus wells are planned for construction, including those included in CLWA's Capital Improvements Program. If operated continuously during the year, the wells not subject to perchlorate contamination have the capability to produce approximately 21,000 AFY (personal communication, L. Takaichi 2004). However, a more realistic production capability is 15,000 AFY due to periodic shutdown for maintenance, monitoring, or storage limitations (personal communication, L. Takaichi 2004). The current groundwater production capability from the Saugus Formation is estimated to be 5,000 AFY during normal years but could reach 15,000 AFY during dry periods or other periods of need (personal communication, L. Takaichi 2004). These capabilities will increase as additional production wells in the Saugus Formation are completed and a response action to perchlorate contamination is implemented.

**Alternative 3, Exchange Desalinated Water for SWP Water (Desalination/Exchange)**

This alternative comprises two primary components in lieu of the Project: (1) CLWA would contribute a portion of the funds needed by another agency to develop a seawater desalination facility along the southern California coast; and (2) up to 41,000 AFY of desalinated water produced by this facility would be exchanged with CLWA for SWP water. A likely partner in such an arrangement would be The Metropolitan Water District of Southern California (Metropolitan). If both parties agreed, CLWA would enter into a contract with Metropolitan indicating that a portion of Metropolitan's annual SWP Table A Amount would be delivered to Castaic Lake for use by CLWA in exchange for CLWA's contribution to a desalination facility to be constructed by Metropolitan. CLWA would treat and distribute this SWP water in existing CLWA facilities, and Metropolitan would use water from the desalination facility in lieu of the SWP water exchanged with CLWA.

Assuming a 50 percent recovery rate, a plant capacity of approximately 73 mgd would be required to produce 41,000 AFY. Depending on the extent of ancillary facilities included at the site, a site of at least 2 acres could be required. In addition to the desalting plant, the coastal facility would likely include new electrical power conveyance and control equipment, ocean water intake and brine disposal structures, and a treated water pumping plant. Total site area could be up to 5 acres. Depending on site location, additional pipelines and related pumping facilities may be required to convey the desalinated water a short distance to the existing Metropolitan distribution facilities.

**Alternative 4, Transfer of a Smaller Table A Amount (Smaller Table A Amount)**

Under this alternative, CLWA would acquire a smaller amount of SWP Table A Amount than under the Project. A transfer of approximately 20,000 AF of SWP Table A Amount was analyzed since it is the approximate mid-point between the amount that would be transferred under the Project and the No Project Alternative. Existing facilities would be used, as described for the Project.

Since the demand for high quality surface water is expected to increase in southern California as a result of anticipated growth, the remaining SWP Table A Amount (21,000 AF) could be acquired and transferred to other (unidentified) portions of urbanized southern California. The Table A Amount not acquired by CLWA would likely be acquired by other agencies with

growing urban water demands. However, the timing, amount, and location of the transfer(s) as well as the associated impacts are speculative and are not evaluated under this alternative.

**Alternative 5, Transfer of a Larger Table A Amount (Larger Table A Amount)**

Under this alternative, CLWA would acquire a larger SWP Table A Amount than under the Project. Such an alternative would require the use of a larger proportion of the SWP facilities and capacities than described for the Project, and would attempt to reduce or avoid the effects of reductions in SWP supplies (during periods of drought) on local groundwater resources. In order to provide an analysis of impacts of a transfer greater than the Project (transfer of 41,000 AF of Table A Amount), a transfer of approximately 60,000 AF of SWP Table A Amount was established for this alternative. This Table A Amount is potentially available from other KCWA member units who have expressed interest in reducing their Table A Amount and have completed CEQA analysis of the sale of this contract right (e.g., Belridge Water Storage District, Berrenda Mesa Water District, and Lost Hills Water District [BWSD 1998; BMWD 1996]). Existing facilities would be used, as described for the Project.

**Environmentally Superior Alternative**

Scenarios 1 and 2 of Alternative 1, the No Project Alternative, would reduce or avoid the significant indirect (growth-related) impacts of the Project, but each would result in greater direct impacts since new groundwater wells, treatment facilities, and associated pipelines would be required. Additionally, each of these scenarios could result in significant unavoidable impacts to groundwater supply and groundwater quality. This alternative would not augment CLWA's water supply and therefore would not meet the Project objectives. Since the direct impacts of the No Project Alternative would be substantially greater than the Project and since it would not meet Project objectives, this alternative is not considered environmentally superior.

Alternative 2, the Increased Groundwater Extractions Alternative, would result in the same indirect impacts as the Project and thus would not reduce or avoid the Project's significant growth-related impacts. It would result in greater direct impacts to many environmental resources because new groundwater wells, treatment facilities, and pipelines would have to be constructed. It also would result in a significant, unavoidable impact to groundwater supply, whereas the Project would result in a beneficial impact to groundwater supply through recharge. This alternative would not augment CLWA's water supply and therefore would not meet the Project objectives. Because the direct impacts of the Increased Groundwater Extractions Alternative would be substantially greater than the Project and since it would not meet Project objectives, this alternative is not considered environmentally superior.

Alternative 3, the Desalination/Exchange Alternative, would result in the same indirect impacts as the Project and thus would not reduce or avoid the Project's significant growth-related impacts. It would result in greater direct impacts to many environmental resources from the construction and operation of a new desalination plant and pipeline. This alternative would augment CLWA's water supply since desalinated water would be exchanged with another water agency's SWP Table A Amount, which would be conveyed to existing CLWA facilities, and therefore would meet the Project objectives. Because the direct impacts of the

Desalination/Exchange Alternative would be substantially greater than the Project, however, this alternative is not considered environmentally superior.

Alternative 4, the Smaller Table A Amount Alternative, would reduce the potentially significant indirect impacts of the Project and would result in similar or lessened direct impacts, as well. This alternative would not meet one of the two Project objectives, however, which is to "Augment CLWA's SWP Table A Amount to meet water demands of existing users and a portion of future water demand from anticipated growth within the CLWA service area." Thus, while this alternative would result in lessened direct and indirect impacts, it does not meet an important basic Project objective[6] and is not considered the environmentally superior alternative.

Alternative 5, the Larger Table A Amount Alternative, would increase the significant indirect impacts of the Project and would result in similar or greater direct impacts, as well. It would meet the Project objectives but would result in greater environmental impacts than the Project and is not considered environmentally superior.

The Project is identified as the environmentally superior alternative that meets Project objectives.

## AREAS OF KNOWN CONTROVERSY

The previous EIR on the Project was decertified because it tiered from the Monterey Agreement Program EIR, which was itself decertified as a result of an appellate court decision. The present EIR does not tier from this or any other EIR, and examines environmental impacts that would occur with and without the change in water allocation criteria implemented as part of the Monterey Amendment. Although the Monterey Amendment continues in operation under the Settlement Agreement, this EIR evaluates a reasonable worst-case scenario of SWP operations without the Monterey Amendment.

The potential for growth inducement as a result of the increased water supply to the CLWA service area is an area of known controversy.

The availability of local water supplies has been the subject of some controversy in the Santa Clarita Valley over the last few years. The water suppliers' consulting engineers recently calculated the availability of local groundwater at 50,000 AFY (Slade 2002) based on updated studies prepared using reasonable, accepted engineering and scientific practices (perchlorate remediation measures and recycled water use were considered in these studies). Some Santa Clarita Valley residents have questioned the conclusions of these studies and claim that only about 32,000 AFY of water is available based on conclusions in an earlier report published in 1986 (Slade 1986). They also claim that water from the Saugus Formation should not be calculated as available on a long-term basis until the perchlorate contamination in a small part of this formation is fully contained or remediated. CLWA, CLWA Santa Clarita Water Division, Newhall County Water District, and Valencia Water Company have received $8 million as reimbursement for litigation costs and studies to determine the cleanup plan for the

6 Under CEQA Guidelines 15126.6, an EIR must describe a range of reasonable alternatives that would feasibly attain most of the basic objectives of the proposed project but would avoid or substantially lessen significant impacts of the project.

perchlorate. CLWA and the retail purveyors are presently identifying the method of cleanup and the costs of cleanup to be paid by the insurance companies of Whitaker Bermite and related parties. It is anticipated the cleanup should be in place by 2006.

## UNRESOLVED ISSUES

No unresolved environmental issues have been identified.

**Table ES-1. Summary of the Project's Environmental Impacts and Mitigation Measures**
(Page 1 of 8)

| *Environmental Resource* | *Location* | *Direct Impacts* | *Indirect Impacts* | *Mitigation Measures* | *Residual Impacts* |
|---|---|---|---|---|---|
| Aesthetic/ Visual Resources | SWP | **Less than significant.** Slight decrease in water stored in San Luis Reservoir from December through June. | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: Less than significant. INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Potential changes to the visual characteristics and resources from development of open space and further urbanization of hillside and natural areas. Potential increase in the amount of night lighting and unwanted glare in presently undeveloped areas. (Growth-related impact) | DIRECT: None required. INDIRECT: Reduced by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None. INDIRECT: Significant unavoidable adverse impacts. |
| Agricultural Resources | SWP | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Potential conversion of agriculture lands to non-agricultural uses or for changes in agricultural zoning by local jurisdictions in order to allow a higher density or intensity of development. (Growth-related impact) | DIRECT: None required. INDIRECT: Reduced by local governments implementing the policies of the County of Los Angeles, County of Ventura, and the Piru general and area plan. | DIRECT: None. INDIRECT: Less than significant. |
| Air Quality | SWP | **Less than significant.** Increased air emissions from the generation of additional electrical power to move water from WRMWSD to CLWA. | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: Less than significant. INDIRECT: None. |

**Table ES-1. Summary of the Project's Environmental Impacts and Mitigation Measures**
(Page 2 of 8)

| *Environmental Resource* | *Location* | *Direct Impacts* | *Indirect Impacts* | *Mitigation Measures* | *Residual Impacts* |
|---|---|---|---|---|---|
| Air Quality (continued) | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Potential increase in air pollutant emissions from transportation and development. (Growth-related impact) | DIRECT: None required.<br>INDIRECT: Reduced by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. Additionally, reduced by compliance with SCAQMD plans. | DIRECT: None.<br>INDIRECT: Significant unavoidable adverse impact. |
| Biological Resources | SWP | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Conversion and degradation of habitat; reduction/local extinction of local native plant and wildlife populations; including sensitive species; introduction of invasive non-native species; disruption of established wildlife corridors and native wildlife nursery sites; impacts on sensitive fish and amphibian populations due to wastewater discharge and polluted runoff; conflicts with local policies and ordinances protecting biological resources. (Growth-related impact) | DIRECT: None required.<br>INDIRECT: Reduced by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. State and federal regulatory agencies permit conditions may reduce significant impacts. | DIRECT: None.<br>INDIRECT: Significant unavoidable impact. |

**Table ES-1. Summary of the Project's Environmental Impacts and Mitigation Measures**
(Page 3 of 8)

| *Environmental Resource* | *Location* | *Direct Impacts* | *Indirect Impacts* | *Mitigation Measures* | *Residual Impacts* |
|---|---|---|---|---|---|
| Cultural Resources | SWP | **Less than significant.** Potential exposure of submerged cultural resources in San Luis Reservoir from December through June. | **No impact.** | DIRECT None required. INDIRECT: None required. | DIRECT: Less than significant. INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Potential disturbance of human remains, archaeological, historical, and paleontological resources by excavation and grading activities associated with future development. (Growth-related impact) | DIRECT: None required. INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None. INDIRECT: Less than significant. |
| Geology and Soils | SWP | **Less than significant.** Slight increase in soil exposed to wind and water erosion at San Luis Reservoir from December through June. | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: Less than significant. INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Potential from: geologic hazards, including fault rupture, seismically induced ground failure, and seiches, as well as causing permanent changes in topography, loss of topsoil, and removal of unique geologic features. (Growth-related impact) | DIRECT: None required. INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None. INDIRECT: Less than significant. |
| Hazards and Hazardous Materials | SWP | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |

**Table ES-1. Summary of the Project's Environmental Impacts and Mitigation Measures**
(Page 4 of 8)

| *Environmental Resource* | *Location* | *Direct Impacts* | *Indirect Impacts* | *Mitigation Measures* | *Residual Impacts* |
|---|---|---|---|---|---|
| Hazards and Hazardous Materials (continued) | CLWA | **Less than significant.** Incremental increase in use of hazardous materials to treat transferred water. | **Significant.** Previously contaminated sites may require the removal or remediation of soils before development. Potential increase in transport, use, and disposal of hazardous materials, along with increased risks of hazardous substance releases. Potential impairment of emergency response plans or emergency evacuation plans. Increased public exposure to wildland fires. (Growth-related impact) | DIRECT: None required.<br>INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: Less than significant.<br>INDIRECT: Less than significant. |
| Land Use and Planning | SWP | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Potential to division of a community or conflict with adopted land use plans. (Growth-related impact) | DIRECT: None required.<br>INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None.<br>INDIRECT: Less than significant. |
| Noise | SWP | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Potential short-term increases from construction and grading activities, increase in traffic-related emissions and changes in land uses. (Growth-related impact) | DIRECT: None required.<br>INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None.<br>INDIRECT: Less than significant. |

**Table ES-1. Summary of the Project's Environmental Impacts and Mitigation Measures**
(Page 5 of 8)

| *Environmental Resource* | *Location* | *Direct Impacts* | *Indirect Impacts* | *Mitigation Measures* | *Residual Impacts* |
|---|---|---|---|---|---|
| Population and Housing | SWP | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: Less than significant. |
| | CLWA | **No impact.** | **Significant.** Potential increase in population and housing. (Growth-related impact) | DIRECT: None required.<br>INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None.<br>INDIRECT: Less than significant. |
| Public Services | SWP | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Potential increase in demand for public facilities and services. (police, fire, schools, and library services). (Growth-related impact) | DIRECT: None required.<br>INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None.<br>INDIRECT: Less than significant. |
| Recreation | SWP | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |

**Table ES-1. Summary of the Project's Environmental Impacts and Mitigation Measures**
(Page 6 of 8)

| *Environmental Resource* | *Location* | *Direct Impacts* | *Indirect Impacts* | *Mitigation Measures* | *Residual Impacts* |
|---|---|---|---|---|---|
| Recreation (continued) | CLWA | **No impact.** | **Significant.** Potential increase in demand for recreational resources. (Growth-related impact) | DIRECT: None required. INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None. INDIRECT: Less than significant. |
| Transporta-tion/Traffic | SWP | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |
| | CLWA | **No impact.** | **Significant.** Potential increase in traffic and the need for new or altered roads, highways, and transportation systems in the Santa Clarita Valley. (Growth-related impact) | DIRECT: None required. INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None. INDIRECT: Significant unavoidable adverse impacts from increased vehicle trips due to growth in the Santa Clarita Valley. |
| Utilities and Service Systems | SWP | **Less than significant.** Additional electricity required to convey water to CLWA. | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: Less than significant. INDIRECT: None. |
| | WRMWSD | **No impact.** | **No impact.** | DIRECT: None required. INDIRECT: None required. | DIRECT: None. INDIRECT: None. |

**Table ES-1. Summary of the Project's Environmental Impacts and Mitigation Measures**
(Page 7 of 8)

| *Environmental Resource* | *Location* | *Direct Impacts* | *Indirect Impacts* | *Mitigation Measures* | *Residual Impacts* |
|---|---|---|---|---|---|
| Utilities and Service Systems (continued) | CLWA | **Less than significant.** Additional demand for water treatment and electrical power to treat and distribute the transferred water within the CLWA service area. | **Less than significant.** Potential increase wastewater generation and demand for wastewater treatment; potential need for new storm water drainage facilities or the expansion of existing facilities. (Growth-related impact)<br>**Significant.** Potential increased demand for solid waste disposal services; potential increased need for potable water treatment facilities. (Growth-related impact) | DIRECT: None required.<br>INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. Impacts to solid waste disposal may not be avoidable unless additional landfill capacity is approved and constructed. | DIRECT: None.<br>INDIRECT: Significant unavoidable adverse impact related to increased demand for solid waste disposal services. |
| Water Resources | SWP | **Less than significant.** Imperceptible or minor change in water quality in the Delta due to minor changes in timing of Delta diversions in some years. However, these changes would fall well within the range of historical and future anticipated SWP diversions from the Delta. | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |

**Table ES-1. Summary of the Project's Environmental Impacts and Mitigation Measures**
(Page 8 of 8)

| *Environmental Resource* | *Location* | *Direct Impacts* | *Indirect Impacts* | *Mitigation Measures* | *Residual Impacts* |
|---|---|---|---|---|---|
| Water Resources (continued) | WRMWSD | **Less than significant.** Minor reduction of SWP Table A supply that has been replaced by other water management actions. Under some extreme conditions this could result in increased reliance on other water sources and groundwater. Increased use of other water and groundwater would result in higher TDS water used and recharged to local groundwater. | **No impact.** | DIRECT: None required.<br>INDIRECT: None required. | DIRECT: None.<br>INDIRECT: None. |
| | CLWA | **Beneficial impact.** Increased imported water supply to meet anticipated demands. Increased SWP supply would replace water that could have otherwise been pumped from groundwater. | **Significant.** Potential increased demand on local groundwater resources during periods of reduced SWP deliveries could result in substantial short-term stressing of groundwater supplies. Potential alteration of surface flows, reduction of aquifer recharge and increased amount and rate of stormwater runoff. Increased flooding and peak flow rates could result in substantial erosion or siltation on- or off-site. (Growth-related impact) | DIRECT: None required.<br>INDIRECT: Mitigated by local governments implementing the policies of the County of Los Angeles, County of Ventura, and City of Santa Clarita general and area plans. | DIRECT: None.<br>INDIRECT: Less than significant. |

Pages omitted.

# 3.15 WATER RESOURCES

As discussed in section 3-0, this EIR's description of the Project's environmental setting includes information from the general timeframe when the January 2003 NOP was issued (referred to as current or present conditions), as well as information describing the environmental setting as it existed when the NOP for the 1999 Supplemental Water Project Final EIR was published (April 1998). Table 3.0-1 describes the key substantive changes in the environmental setting, if any, that occurred between 1998 and the present for each environmental resource analyzed in this EIR. The differences relevant to water resources are summarized below for the three geographic areas under consideration.

**State Water Project**

Total Table A deliveries fluctuated, ranging from a low of 1,546,740 AF in 2001 to a high of 3,714,230 AF in 2003. SWP Table A Amounts were transferred among SWP Contractors, including MWD to Coachella Valley Water Authority – 35,000 AF; Belridge Water Storage District to Zone 7 – 2,219 AF; and Tulare Lake Basin Water Storage District to Zone 7 – 400 AF. The PCL litigation challenging the Monterey Amendment was settled and essentially leaves these amendments in place (see sections 12.2 and 1.4.2 for a more complete description).

**Wheeler Ridge-Maricopa Water Storage District**

Water supplies are generally the same, although WRMWSD has increased participation in other, more cost effective, water management options. In 1998, such water management activities could have supplied WRMWSD with an additional 59,500 AFY, and 106,000 AFY in 2002. WRMWSD's contract with KCWA from SWP water was 197,088 AF in 2002. WRMWSD's contract with KCWA was 238,088 AF of "firm supply" in 1998.

**Castaic Lake Water Agency**

Water supply sources are generally the same, although CLWA's SWP Table A Amount was was increased by 41,000 AF due to the Project. In 1998, CLWA's average year SWP supply was estimated to be 46,500 AF based on available DWR model analysis. CLWA's average year SWP supply now is estimated to be 68,300 AF based on new DWR model results and Project implementation. In 1998, the total water demand in 2010 was projected to be approximately 106,300 AF. Future demand now is expected to be approximately 82,400 AF in 2010 and 102,500 AF by 2020.

## 3.15.1 Environmental Setting

### *3.15.1.1 State Water Project*

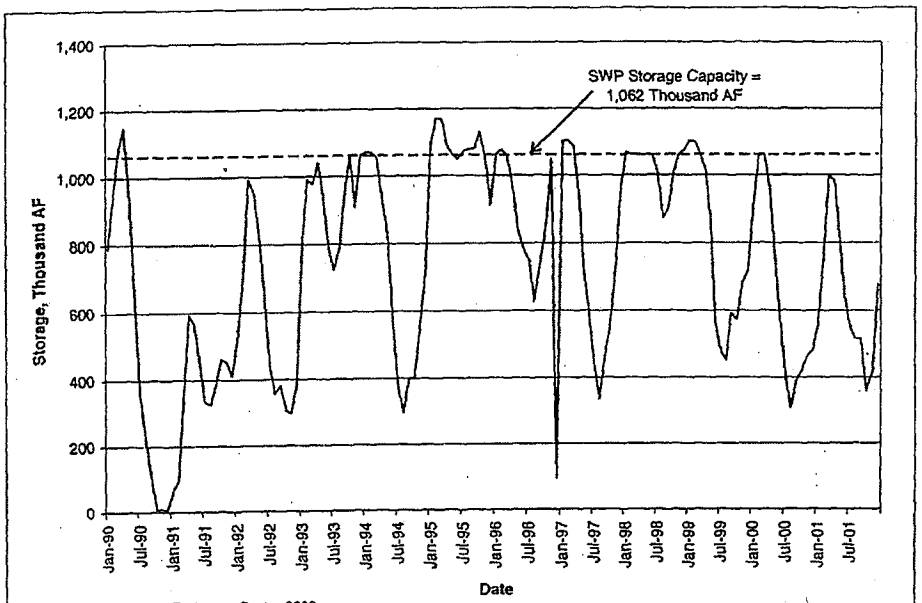
*SWP Facilities*

The SWP is a water supply, storage, and distribution system that includes 28 storage facilities, reservoirs, and lakes; 20 pumping plants; six pumping-generating plants and hydroelectric power plants; and about 660 miles of aqueducts and pipelines (DWR 2001a). Principal SWP facilities are shown on Figure 1.3-1.

The primary water source for the SWP is within the drainage of the Feather River, a tributary of the Sacramento River, where runoff is stored behind Oroville Dam. Water released from Oroville Dam flows down natural channels to the Delta. In the southern Delta, water is pumped into the 444-mile-long California Aqueduct at the Clifton Court Forebay by the Banks Pumping Plant (or by agreement with the U.S. Bureau of Reclamation [USBR], at the Central Valley Project's [CVP] Tracy Pumping Plant). SWP water exports for users south of the Banks and Tracy pumping plants are currently limited by a series of water quality and operational constraints, governed primarily by the SWRCB's Water Right Decision 1641, as amended. Decision 1641 was adopted by the SWRCB in 1999; prior to that time, SWP water exports from the Delta were limited by the SWRCB's Water Right Decision 1485 (adopted in 1978), Order Water Right (WR) 95-6 (adopted in 1995), and Order WR 98-09 (adopted in 1998).

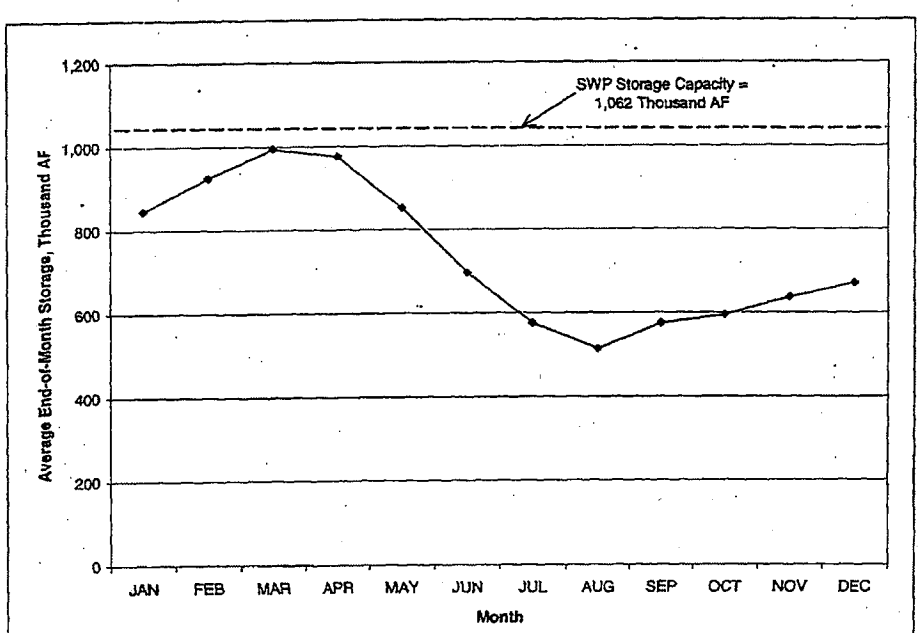
From the southern Delta facilities, water in the California Aqueduct travels along the west side of the San Joaquin Valley and is delivered directly to SWP Contractors or is stored in San Luis Reservoir, the SWP's main storage facility south of the Delta. San Luis Reservoir, located near Los Banos, is an off-stream storage reservoir with a total storage capacity of more than 2 million AF (of which approximately 1,062,000 AF are allocated to the SWP; the remainder is allocated to the CVP [DWR 2001a]).

In general, the SWP is operated to fill storage reservoirs during the high runoff months of the winter and early spring. Regulatory requirements for the Delta and associated operational constraints also affect the timing and ability to fill reservoirs south of the Delta. Under current operating conditions, including Decision 1641, SWP diversions from the Delta are substantially reduced as of April 15 of each year. As a result, the SWP is operated to store as much water as possible in San Luis Reservoir prior to April 15. The stored water is then released to meet Contractor demands during the high-demand summer and fall months to supplement the more limited pumping from the Delta during those months. Figure 3.15-1 shows the volume of SWP water stored in San Luis Reservoir for the period between 1990 and 2001. Figure 3.15-2 shows the average end-of-month SWP storage in San Luis Reservoir from 1990 to 2001. As is shown on these figures, San Luis Reservoir SWP storage levels vary considerably, both during the year and from year to year. From 1990 to 2001, SWP storage in the reservoir has ranged from approximately zero to more than 1.1 million AF.




*Source:* California Data Exchange Center 2002.
Note: SWP storage can exceed its capacity when it borrows unused capacity from the CVP.
Total San Luis Reservoir storage capacity is 2,028 thousand AF.

**Figure 3.15-1. SWP Storage in San Luis Reservoir, 1990 to 2001**




*Source:* California Data Exchange Center 2002.

**Figure 3.15-2. SWP Storage in San Luis Reservoir, 1990 to 2001 Average End-of-Month Storage**

Water is conveyed southward from San Luis Reservoir via the California Aqueduct to the primarily agricultural users in the San Joaquin Valley and the primarily urban regions of the Central Coast and southern California. Water is diverted from the Aqueduct and delivered directly to SWP Contractors, including KCWA, in the central and southern San Joaquin Valley at various locations along the Aqueduct. The Aqueduct traverses the west side of the San Joaquin Valley, and water is pumped through a series of four pumping plants (Dos Amigos, Buena Vista, Teerink, and Chrisman) before reaching the Edmonston Pumping Plant. The capacity in these reaches of the Aqueduct ranges from 10,000 cubic feet per second (cfs) at the northern end to approximately 4,400 cfs at the Edmonston Pumping Plant. The Edmonston Pumping Plant pumps water over the Tehachapi Mountain Range, and the California Aqueduct then divides into the East Branch and the West Branch. Water intended for use by CLWA is conveyed through the West Branch through Quail and Pyramid lakes and then to Castaic Lake, the terminus for the West Branch.

Quail and Pyramid lakes are located between the KCWA turnouts for deliveries to WRMWSD and the CLWA turnout on the West Branch of the California Aqueduct. Because of Quail Lake's limited storage capacity (approximately 7,800 AF) the lake is primarily used for the re-regulation of Aqueduct flows. Pyramid Lake, which has a storage capacity of approximately 171,200 AF, is used to provide an emergency water supply to the SWP Contractors that receive deliveries from the West Branch in the case of a major supply system outage, and is used in the operation of the Castaic Power Plant, located between Pyramid and Castaic lakes.

Castaic Lake has a storage capacity of approximately 323,700 AF. As shown on Figure 3.15-3, from 1990 to 2001, storage has ranged from a minimum of approximately 150,000 AF to a maximum of approximately 320,000 AF. The average end-of-month storage from 1990 to 2001 in Castaic Lake is shown on Figure 3.15-4. The reservoir is operated to provide regulatory storage to meet peak deliveries during the summer months for the three SWP Contractors that receive water from Castaic Lake (CLWA, The Metropolitan Water District of Southern California [MWD], and the Ventura County Flood Control District [VCFCD]), and to provide an emergency water supply in the case of a major supply system outage. As part of the Monterey Amendment, these three SWP Contractors have access to 160,000 AF of the storage from Castaic Lake as "flexible storage," which they may withdraw in addition to their allocated SWP supplies and which they must replace within five years of any withdrawal. Local runoff captured in Castaic Lake is managed in compliance with an agreement between DWR and the holders of prior water rights. From 1990 to 2000, SWP deliveries to CLWA from Castaic Lake averaged approximately 19,200 AF, or approximately 6 percent of the total annual SWP deliveries from the lake (see Table 3.15-1). From 1990 to 2000, the majority of the SWP water delivered from the lake (approximately 93 percent) was delivered to MWD due to its relatively larger Table A Amount and storage rights in Castaic Lake.

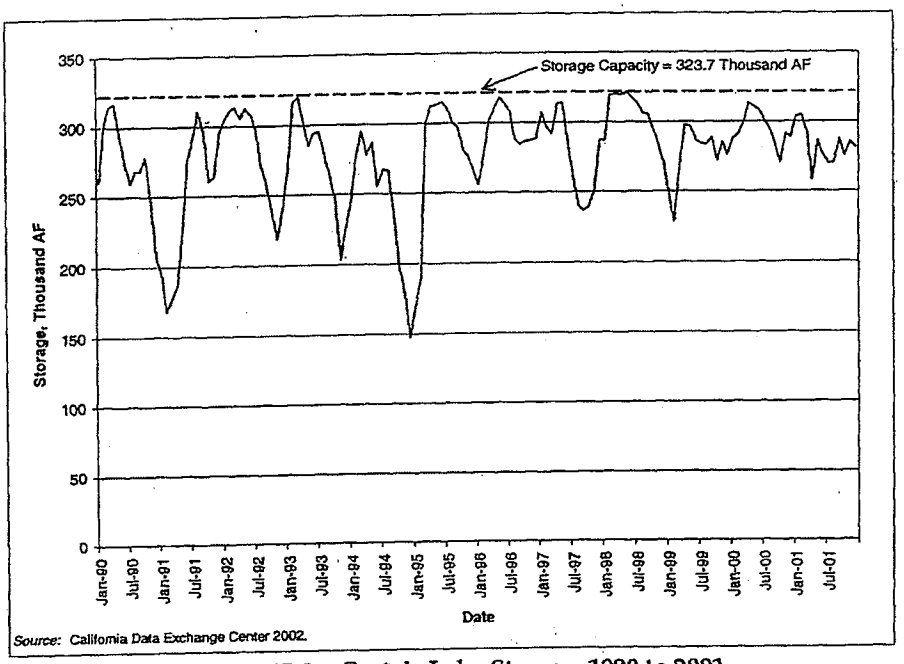



Figure 3.15-3. Castaic Lake Storage, 1990 to 2001

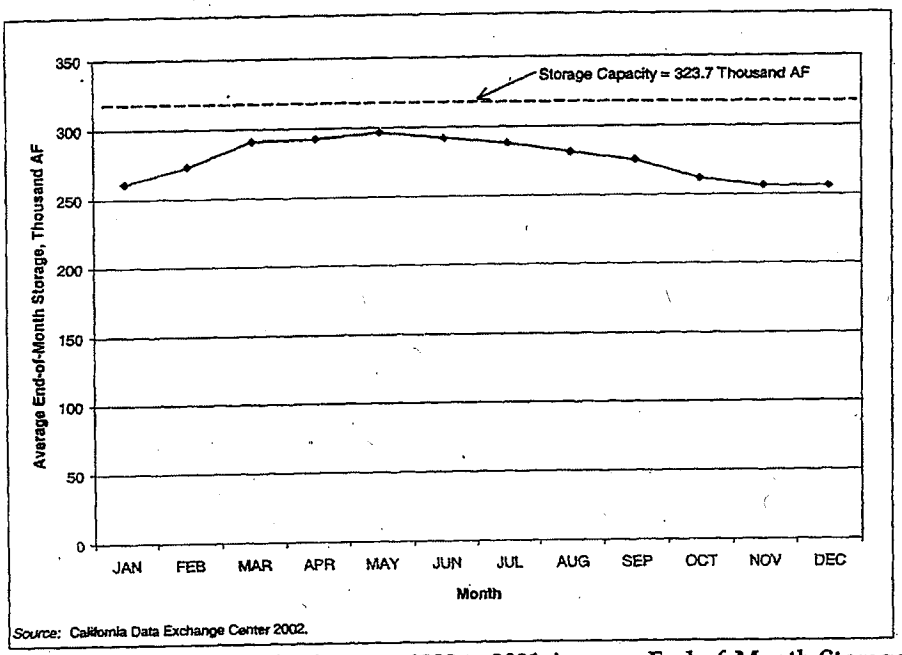



Figure 3.15-4. Castaic Lake Storage, 1990 to 2001 Average End-of-Month Storage

Table 3.15-1. Annual SWP Water Deliveries from Castaic Lake by Contractor, 1990 to 2000

| | CLWA | MWD | VCFCD | Other[1] | Total | CLWA as a % of Total |
|---|---|---|---|---|---|---|
| 1990 | 22,139 | 764,380 | 0 | 0 | 786,519 | 2.81 |
| 1991 | 3,846 | 257,835 | 0 | 1,240 | 262,921 | 1.46 |
| 1992 | 14,812 | 420,849 | 0 | 0 | 435,661 | 3.40 |
| 1993 | 13,787 | 437,470 | 0 | 0 | 451,257 | 3.06 |
| 1994 | 14,919 | 475,900 | 0 | 0 | 490,819 | 3.04 |
| 1995 | 17,747 | 139,882 | 0 | 0 | 157,629 | 11.26 |
| 1996 | 18,448 | 267,618 | 0 | 0 | 286,066 | 6.45 |
| 1997 | 22,842 | 271,379 | 1,850 | 27,130 | 323,201 | 7.07 |
| 1998 | 19,782 | 187,277 | 1,850 | 0 | 208,909 | 9.47 |
| 1999 | 28,813 | 327,001 | 1,850 | 0 | 357,664 | 8.06 |
| 2000 | 33,674 | 632,993 | 1,848 | 0 | 668,515 | 5.04 |
| Average | 19,164 | 380,235 | 673 | 2,579 | 402,651 | 5.56 |

Source: DWR 2002.
1. Includes deliveries from Castaic Lake via exchange. These deliveries were made by the Santa Barbara County Flood Control and Water Conservation District in 1991 via exchange with VCFCD, and by the Coachella Valley Water District and Desert Water Agency in 1997 via exchange with MWD.

*Water Supply and Demands*[1]

As described in section 1.4.2, in the early 1960s, DWR began entering into individual Water Supply Contracts with various urban and agricultural public water supply agencies, known as Contractors. The total planned annual delivery capability of the SWP and the sum of all Contractors' maximum Table A Amounts specified in the Water Supply Contracts were approximately 4.2 million AF. The initial SWP facilities were designed to meet Contractors' water demands in the early years of the project, with the construction of additional facilities planned as demands increased. Water deliveries to Contractors began as initial SWP facilities were completed in the late 1960s and early 1970s; essentially no additional SWP storage facilities have been constructed since that time.

As shown on Table 3.15-2, from 1990 to 2003, actual SWP annual deliveries of Table A supplies to Contractors have ranged from approximately 550,000 AF in 1991 to approximately 3.7 million AF in 2003. Many Contractors did not request delivery of their full Table A Amount during this period. Climatic conditions and other factors can significantly alter the availability of SWP water in any year. The annual allocations of water made by DWR are based on that year's hydrologic conditions, the amount of water in storage in the SWP system, and Contractors' requests for SWP supplies. Contractors' water needs vary from year to year, and many

1 Bulletin 132-01, *Management of the California State Water Project*, is the most recent published data by DWR for SWP operations, including SWP deliveries to Contractors. Because Bulletin 132-01 covers SWP activities through calendar year 2000, the baseline information presented in this EIR for SWP operations includes information through calendar year 2000.

Contractors did not request delivery of their full Table A Amount in a number of years during this 14-year period.

**Table 3.15-2. SWP Annual Table A Deliveries, 1990 to 2003**

| | *Agricultural Contract Holders* | | *M&I Contract Holders* | | *Total Table A Deliveries (AF)* |
|---|---|---|---|---|---|
| | *Table A Deliveries (AF)* | *Allocation Percentage (%)* | *Table A Deliveries (AF)* | *Allocation Percentage (%)* | |
| 1990 | 706,080 | 50 | 1,876,070 | 100 | 2,582,150 |
| 1991 | 12,440 | 0 | 536,670 | 30 | 549,110 |
| 1992 | 509,810 | 45 | 961,650 | 45 | 1,471,460 |
| 1993 | 1,250,370 | 100 | 1,064,870 | 100 | 2,315,240 |
| 1994 | 614,360 | 53 | 1,134,990 | 53 | 1,749,350 |
| 1995 | 1,165,520 | 100 | 801,570 | 100 | 1,967,090 |
| 1996 | 1,369,190 | 100 | 1,145,640 | 100 | 2,514,830 |
| 1997 | 1,067,320 | 100 | 1,258,460 | 100 | 2,325,780 |
| 1998 | 860,720 | 100 | 864,800 | 100 | 1,725,520 |
| 1999 | 1,333,590 | 100 | 1,405,300 | 100 | 2,738,890 |
| 2000 | 1,177,200 | 90 | 2,022,700 | 90 | 3,199,900 |
| 2001 | 383,840 | 39 | 1,162,900 | 39 | 1,546,740 |
| 2002 | 827,128 | 70 | 2,059,886 | 70 | 2,887,014 |
| 2003 | 1,064,267 | 90 | 2,649,966 | 90 | 3,714,230 |

*Source:* For 1990 to 2000, DWR 2002. For 2001, DWR 2004a. For 2002, DWR 2003c. For 2003, DWR 2004b.

Under conditions specified in the Water Supply Contracts, DWR can make water available to SWP Contractors above and beyond a Contractor's Table A supply. Table 3.15-3 provides an overview of the various types of SWP water supplies discussed throughout this EIR.

In 1998, DWR estimated that annual deliveries to SWP Contractors would average approximately 3.1 million AF (based on estimates of then-existing levels of Contractor demands and land and water use upstream of the Banks Pumping Plant[2], with existing facilities operated under the constraints of Order WR 95-6; DWR 1998). This estimate is generally consistent with DWR's recent SWP Delivery Reliability Report (DWR 2003b). In this report, DWR estimated that the SWP currently can be expected to deliver an average annual supply of approximately 2.96 million AF, based on a 2001 level of Contractor demand and upstream land and water use, with existing facilities operated under existing constraints (DWR 2003b).

2 Land and water use upstream of the Banks Pumping Plant affects the amount of water flowing into the Delta. In general, increases in the amount of water flowing into the Delta can increase SWP supplies, while decreases in the amount of water flowing into the Delta (due to increased water use upstream or a variety of other factors) can decrease SWP supplies.

1 **Table 3.15-3. SWP Surplus and Other Water Types**

| | | |
|---|---|---|
| **Surplus Water** | SWP water that can be made available to Contractors when water and capacity are available in excess of SWP storage needs and Table A supplies. See below for terminology for, and descriptions of, specific types of surplus water. Surplus water terminology changed with implementation of the Monterey Amendment. | |
| | **Without Monterey Amendment (Including With Implementation of Article 18(b))** | **With Monterey Amendment** |
| | **Scheduled surplus water** - Water that DWR determined to be available, in addition to Table A supplies, which was scheduled for delivery throughout the year (in the same manner as Table A supplies). This water was generally available only during the early years of the SWP (when Contractor demands were low). | Category deleted as part of the Monterey Amendment. Given increased Contractor demands, this water was physically no longer available. |
| | **Unscheduled surplus water** - Water that DWR made available when water and capacity were available in excess of SWP storage needs and Table A supplies. This water is only available for limited time periods, generally only in the winter or early spring when Contractors demands are low, and only under specific conditions that do not occur on an annual basis. | **Article 21 water** - Same as unscheduled surplus water. Article 21 water was defined under the Monterey Amendment as "interruptible water" but is more commonly referred to as "Article 21 water." |
| **Carryover Water** | SWP Table A water that is allocated to, and paid for by, a Contractor in one year, but is stored in SWP supply reservoirs (when storage is available) for use by that Contractor in a following year. | |
| **DWR Dry Year Purchase** | Water from DWR's Dry Year Water Purchase Program, through which water is purchased by DWR in shortage years from willing sellers in areas that have available supplies, and is then sold by DWR to Contractors willing to purchase those supplies. | |
| **Flexible Storage (Added as part of the Monterey Amendment)** | Storage available to Contractors that share in repayment of the costs of terminal reservoirs (Castaic and Perris lakes). These Contractors may withdraw water from their share of flexible storage, in addition to any other SWP supplies available to the Contractor. The Contractor must replace any water it withdraws from flexible storage within five years. Flexible storage was added to the Water Supply Contracts as part of the Monterey Amendment. CLWA may withdraw up to 4,684 AF of water from Castaic Lake as flexible storage. | |
| **Turnback Pool Water (Added as part of the Monterey Amendment)** | Water sold or purchased through the SWP Turnback Pool. The Turnback Pool is a program in which Contractors with allocated Table A supplies that are in excess of their needs in a given year may turn back that excess supply for purchase by other Contractors that need additional supplies that year. The Turnback Pool can make water available in all types of hydrologic years, although there is generally less excess water turned back in dry years. The Turnback Pool was created as part of the Monterey Amendment. | |

2 *Water Quality*

3 Water quality in the California Aqueduct is primarily a reflection of the quality of water
4 diverted from the Delta. Wet hydrologic years have lower concentrations of total dissolved

solids (TDS[3]) and other constituents relative to drier hydrologic years due to higher Delta outflows pushing the Delta's seawater/fresh water interface further downstream. Water quality sampling data are available at various locations in the California Aqueduct from the California Data Exchange Center (CDEC) operated by DWR. Table 3.15-4 summarizes the water quality data at the Banks Pumping Plant, Check 29 on the California Aqueduct (the nearest upstream location to WRMWSD), and at Castaic Lake from 1990 to 2001.

**Table 3.15-4. SWP Water Quality Summary based on Monthly Data for the Banks Pumping Plant, Check 29, and Castaic Lake, 1990 to 2001**

| *Constituent*[1] | *MCL*[1] | *Harvey Banks Delta Pumping Plant* | | *Check 29*[2] | | *Castaic Lake*[3] | |
|---|---|---|---|---|---|---|---|
| | | AVERAGE | RANGE | AVERAGE | RANGE | AVERAGE | RANGE |
| Chloride[4] (mg/L) | 250 | 82.27 | 12 to 162 | 85.05 | 3 to 170 | 77.64 | 41 to 119 |
| Nitrate + Nitrite, (mg/L) | 10 | 3.33 | 0.13 to 13 | 2.909 | 0.1 to 8.9 | 1.18 | 0.044 to 3.1 |
| TDS[4] (mg/L) | 500 | 276.12 | 85 to 466 | 330.55 | 66 to 687 | 386.59 | 239 to 429 |
| Arsenic[5] (mg/L) | 0.010 | 0.002 | 0.001 to 0.01 | 0.002 | 0.001 to 0.017 | 0.002 | 0.002 to 0.008 |
| Selenium (mg/L) | 0.05 | 0.001 | 0.001 to 0.002 | 0.005 | 0.001 to 0.1 | 0.001 | 0.001 to 0.001 |

*Source:* Personal communication, C. Erickson 2003.

1. An MCL (Maximum Contaminant Level) is the maximum permissible level of a contaminant in drinking water that is delivered to any user of a public water system.
2. Check 29 is located near Highway 119, north of the Buena Vista Pumping Plant and south of the Coastal Aqueduct.
3. Castaic Lake data were taken from MWD's inlet pipe and the outlet tower.
4. The chloride and TDS standards are secondary standards, which are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards but does not require compliance. States may choose to adopt them as enforceable standards, however.
5. On January 22, 2001, EPA adopted a new standard for arsenic in drinking water at 0.010 milligrams per liter (mg/L), replacing the previous standard of 0.050 mg/L. The rule became effective on February 22, 2002. Systems must comply with the new 0.010 mg/L standard is January 23, 2006 (EPA 2002).

The beneficial uses[4] designated by the Central Valley Regional Water Quality Control Board (CVRWQCB) for the California Aqueduct include municipal, agricultural, industrial, recreational (except for canoeing and rafting), and wildlife habitat uses (CVRWQCB 1998). The San Luis Reservoir has the same beneficial uses designated for the Aqueduct except that the reservoir does not have an industrial processing use. San Luis Reservoir is also designated as a

3 TDS is a measure of the total amount of minerals, organic matter, and nutrients that are dissolved in water. The dissolved solids concentration commonly is called the water's salinity and is classified as follows: fresh, 0-1,000 mg/L; slightly saline, 1,000-3,000 mg/L; moderately saline, 3,000-10,000 mg/L; very saline, 10,000-35,000 mg/L; and briny, more than 35,000 mg/L.

4 The Porter-Cologne Water Quality Control Act gave the SWRCB authority over water quality within California and established nine regional water quality control boards. The regional boards prepare water quality plans (called basin plans) for their region that identify the beneficial uses of water to be protected, establish water quality objectives (limits or levels of water constituents based on both state and federal laws), and define a program to implement water quality objectives.

warm freshwater fishery. The beneficial uses designated by the Los Angeles Regional Water Quality Control Board (LARWQCB) for Castaic and Pyramid lakes include municipal, agricultural, industrial, groundwater recharge, freshwater replenishment of surface waters to maintain quality or flow, power, recreational activities, warm and cold water fisheries, wildlife habitat and fish spawning, and rare species habitat (LARWQCB 1994).

### *3.15.1.2 Wheeler Ridge-Maricopa Water Storage District*

*Facilities and District Areas*

WRMWSD receives SWP water through 16 separate turnouts along the California Aqueduct via KCWA's Water Supply Contract with DWR. The WRMWSD distribution system consists of a series of pipelines, pumping plants, canals, and related facilities to deliver surface water from the California Aqueduct to approximately 72,000 acres of contract lands within the district. Contract lands are those lands within the district where landowners have executed long-term contracts with WRMWSD for the delivery of surface water, including SWP water, by the WRMWSD distribution system. These contract lands rely mainly on surface water to meet water demands, although many of the landowners use groundwater to supplement supplies when adequate surface water supplies are not available. Non-contract lands, those lands that do not hold long-term contracts for surface water, rely mainly on groundwater supplies to meet water demands. Surface water, including SWP water when available, can be delivered to certain non-contract lands within the district (generally those lands that historically have held contracts) via the existing WRMWSD distribution system.

Owners of contract lands pay an annual fixed cost based on the amount of land specified in the contract and annual variable costs based on the amount of water received by a particular contract land holder. Contract holders are required to pay the annual fixed cost regardless of the amount of water delivered to their land. Because contract holders can use local groundwater to irrigate their lands, the decision by individual landowners to enter into a contract (or likewise reduce a contract amount or cancel a contract), or to order surface water from WRMWSD instead of using local groundwater is predominantly an economic decision.

WRMWSD delivers untreated surface water predominantly for agricultural uses. Water delivered by WRMWSD is not intended for municipal or potable use without additional treatment.

*Water Supply*

WRMWSD obtains its water supplies from the SWP, other surface water sources, and groundwater sources, and delivers water to agricultural and industrial users within the district. WRMWSD also participates in a variety of other water management activities, including groundwater banking programs outside of the district and other in-lieu and direct groundwater recharge programs within the district.

LOCAL SURFACE WATER

WRMWSD is located along Wheeler Ridge and east of the Tejon Hills in southern Kern County. Sandy, Bitterwater, Santiago, Pleitito, Pleito, Salt, Tecuya, Grapevine, Pastoria, Tunis, El Paso,

Liveoak, and Caparell creeks flow from the south into the district; and Tejon Creek flows from the east into the district. Most of these creeks are intermittent and do not provide substantial water for irrigation or conveyance for irrigation water. Floods occur along the creeks and in areas where sheetflow may occur during high intensity rainfall (KCWA 1998).

The water quality of most of the streams entering the district is generally suitable for irrigation. Because these streams are ephemeral, however, they cannot be used as a reliable source of irrigation water supply for large-scale irrigation (KCWA 1998).

GROUNDWATER

Deep groundwater wells in the district initially were drilled in the mid-1940s. Over the next 20 years, groundwater was the primary water supply in the southern Kern County area. As a result, the groundwater levels declined by 150 to 200 feet (Bookman-Edmonston Engineering, Inc. [BE] 1995). In the late 1960s, the annual groundwater overdraft was estimated to be about 112,000 AF (BE 1995). Use of SWP water has allowed groundwater levels to rise to levels equal to, or above, those observed prior to the availability of SWP water (BE 1995).

The San Joaquin Valley is underlain by a large aquifer system generally referred to as the San Joaquin Valley Groundwater Basin. DWR has divided the San Joaquin Valley Groundwater Basin into smaller groundwater basins based on hydrologic differences (such as water quality and rate of movement of water through the basin). The Kern County Groundwater Basin is the part of the San Joaquin Valley Groundwater Basin that underlies the district. The basin is bounded on the north by the Kern County line and the Tule Groundwater Basin, on the east and southeast by the granitic bedrock of the Sierra Nevada and Tehachapi Mountain ranges, and on the west and southwest by the marine sediments of the San Emigdio and Coast Mountain ranges (DWR 2003a). The surface area of the basin is approximately 1.945 million acres, or 3,040 square miles (DWR 2003a). Total water in storage within the basin is estimated to be 40 million AF, and the dewatered (available) aquifer storage is estimated to be 10 million AF (DWR 2003a). Recharge to the basin results from the seepage of surface water from local streams along the eastern extent of the basin and the Kern River, as well as seepage of surface water from agriculture-related land uses, which is the largest contributor to recharge (DWR 2003a).

The White Wolf Groundwater Basin, a sub-basin to the Kern County Groundwater Basin, underlies the eastern portion of the district. The White Wolf sub-basin is separated from the remainder of the Kern County Groundwater Basin to the north by the White Wolf Fault, and to the southwest by the Springs Fault. The White Wolf Fault historically has been considered a barrier to movement of groundwater from the White Wolf sub-basin to the rest of the Kern County basin (BE 1967; BE 1975). Recent studies have indicated that the White Wolf Fault may act as only a partial barrier to groundwater flow, and only when the aquifer is stressed by pumping (Hagan 2001). The surface area of the White Wolf basin is approximately 52,000 acres (BE 1975). The volume of groundwater in storage has been estimated to be 2.5 million AF (BE 1975). Recharge to the White Wolf basin results from seepage of surface water from local streams and seepage of surface water from agriculture-related land uses.

IMPORTED WATER

KCWA holds the Water Supply Contract through which WRMWSD receives SWP water. KCWA's SWP Table A Amount in 2003 was 1,000,949 AF, and was 1,087,730 AF in 1998. This reduction in Table A Amount was due to several Table A Amount transfers KCWA completed with SWP Contractors since early 1999 consistent with the terms of the Monterey Amendment, including the 41,000 AF transferred to CLWA that is the subject of this EIR. WRMWSD's contract with KCWA included 263,200 AF of SWP Table A Amount in 1971[5]. This quantity was reduced to 251,370 AF in 1988, to 238,088 AF in 1996, and to 197,088 AF in 2000, after the Project was implemented.

Table 3.15-5 summarizes SWP Table A deliveries from 1990 through 2001. From 1990 to 1999 (before the Project was implemented), the SWP deliveries by WRMWSD averaged about 137,360 AF, with a minimum of zero AF in 1991 to a maximum of about 198,100 AF in 1997.

OTHER WATER MANAGEMENT ACTIONS

WRMWSD participates in a variety of other water management actions, including groundwater banking both within and outside of the district. Through its groundwater banking program, WRMWSD stores water when available and draws on that water in dry years to reduce shortages. WRMWSD's other water management actions consist of the following: ongoing in-lieu groundwater recharge within the district through delivery of surface water, when available, to non-contract lands; groundwater wells available to WRMWSD starting in 1992 and additional wells developed or acquired by WRMWSD since 1992; participation in the Kern Water Bank beginning in 1995; participation in the Pioneer Groundwater Banking Project initiated in 1997; and participation in the Berrenda Mesa Project beginning in 1999. These water management actions provide water supplies above and beyond the additional supplies that may be obtained from purchases and exchanges. In 1998, these water management actions could have supplied WRMWSD with an additional 59,500 AF, and by 2001 the amount had increased to over 88,000 AF. In 2002, the amount available from these other water management actions was over 106,000 AF.

Table 3.15-5 summarizes deliveries of water from these other water management actions from 1990 to 2001.

TOTAL SUPPLY

Table 3.15-5 summarizes the annual amount of SWP supply and other water supplies (such as the User Input Program[6], other transfers and exchanges, and other water management actions) available to WRMWSD, and the amount of water delivered within the district from 1990 to 2001. As identified in this table, except for 1990 and 1991, both drought years, WRMWSD's

5 As discussed in Chapter 1, the term Table A Amount in connection to WRMWSD is used for brevity. The parallel term used in the KCWA—WRMWSD member unit contract is "Contract Entitlement," sometimes referred to as "Table 1 Entitlement."

6 The User Input Program allows water users within the district to deliver water into the WRMWSD distribution system. The water user is then credited with an equal amount of water, less any losses, to be delivered to the user by WRMWSD within the same calendar year.

**Table 3.15-5. Summary of Annual SWP and Other Water Supply to WRMWSD and Delivered within the District, 1990 to 2001**
(all values in AF except percentages)

| Year | Water Supply | | | | | Water Delivered | | | | Table A Water Delivered as a Percent of Table A Supply | Total Delivered as a Percent of Total Supply |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SWP Table A Amount (AF) | SWP Allocation Percent[1] | SWP Table A Water Supply[2] (a) | Other Water Supply[3] (b) | Total Supply (a + b) | SWP Table A Water Delivered (c) | Carryover Water Delivered (d) | Other Water Delivered[3] (e) | Total Delivered (c + d + e) | | |
| 1990 | 251,370 | 50% | 126,535 | 60,888 | 187,423 | 126,544 | 40,884 | 20,004 | 187,432 | 100% | 100% |
| 1991 | 251,370 | 0% | 0 | 66,656 | 66,656 | 0 | 0 | 66,656 | 66,656 | N/A[4] | 100% |
| 1992 | 251,370 | 45% | 113,117 | 18,431 | 131,548 | 107,504 | 1,382 | 17,048 | 125,934 | 95% | 96% |
| 1993 | 251,370 | 100% | 251,370 | 22,774 | 274,144 | 133,600 | 10,370 | 2,555 | 146,525 | 53% | 53% |
| 1994 | 251,370 | 53% | 133,226 | 50,544 | 183,770 | 132,316 | 0 | 28,248 | 160,564 | 99% | 87% |
| 1995 | 251,370 | 100% | 251,370 | 49,614 | 300,984 | 161,024 | 0 | 1,114 | 162,138 | 64% | 54% |
| 1996 | 238,088 | 100% | 238,088 | 60,244 | 298,332 | 191,279 | 11,319 | 425 | 203,023 | 80% | 68% |
| 1997 | 238,088 | 100% | 238,088 | 59,740 | 297,828 | 198,065 | 0 | 240 | 198,305 | 83% | 67% |
| 1998 | 238,088 | 100% | 238,088 | 63,111 | 301,199 | 145,605 | 949 | 2,738 | 149,292 | 61% | 50% |
| 1999 | 238,088 | 100% | 238,088 | 66,162 | 304,250 | 177,702 | 0 | 4,868 | 182,570 | 75% | 60% |
| 2000 | 197,088 | 90% | 177,379 | 77,013 | 254,392 | 165,090 | 2,579 | 16,260 | 183,929 | 93% | 72% |
| 2001 | 197,088 | 39% | 76,864 | 114,025 | 190,889 | 73,247 | 3,441 | 61,640 | 138,508 | 96% | 73% |

1. SWP allocation (i.e., the percent of Table A Amount that each Contractor could have received based on that year's supply availability and Contractor requests), as determined by DWR for the year. Based on agricultural Table A allocations for years prior to implementation of the Monterey Amendment in 1996.
2. SWP Table A water available equals SWP Table A Amount multiplied by the SWP allocation percentage.
3. Other water includes the following: SWP surplus water (unscheduled surplus water/Article 21 water); SWP Carryover water (refer to Table 3.15-3); WRMWSD wells; Blanca Rosa Improvement District wells; User Input Program water; Kern Water Bank; Pioneer Groundwater Banking Project; Berrenda Mesa Project; and other miscellaneous water supplies such as water purchased from the Drought Water Bank, and other water transfers and purchases. Of these sources, Article 21 water, Carryover water, other miscellaneous water supplies, and to some extent User Input Program water is not available for use in future years.
4. SWP water (Table A or surplus) was not available to Agricultural Contractors in 1991; therefore, no SWP water was delivered in this year.

water supply (both SWP Table A supply and total supply) has been greater than the amount of water delivered within the district.

*Water Demand*

A variety of factors, including the cost and availability of different water sources, the anticipated crop market value, anticipated or existing crop subsidies, and other factors (such as labor cost, regulation of the use of certain chemicals, etc.) are considered by farmers in the determination to plant or fallow fields, and to plant certain crops. Therefore, water demands within the district can vary substantially from year to year depending on irrigated acreage and the types of crops grown. Refer to section 3.2, Agricultural Resources for further discussion of crop types and irrigated acres within the district. In addition, demands within the district can vary depending on local hydrologic and climatic conditions (e.g., amount and timing of rainfall and local temperatures).

WRMWSD has estimated that under favorable economic conditions, demands within the contract lands are approximately 180,000 to 190,000 AF (personal communication, W. Taube 2002). In only four years from 1990 to 1999 (prior to the Project), did WRMWSD deliver greater than 180,000 AF of SWP water, indicating that favorable economic conditions occurred approximately 40 percent of the time. Demands within the district vary from year to year depending on agricultural economic conditions and hydrologic conditions (amount and timing of local rainfall), but demands within the district are not anticipated to materially increase in the future because the suitable agricultural lands within the district are already in agricultural production, and because WRMWSD does not provide potable water.

*Water Quality*

WRMWSD is within the jurisdiction of the CVRWQCB, Region 5c. Within the district, there are no impaired water bodies or established Total Maximum Daily Load (TMDL) programs[7] (CVRWQCB 1995, SWRCB 1998). Local surface water is of generally good quality. Water quality of imported supplies is primarily dependent on the SWP water quality, which is discussed above.

Groundwater quality varies across the district, and there are portions of the district in which groundwater is not used due to poor quality. These areas are generally located in the most westerly portions of the district. Within the district, the Kern County Groundwater Basin has TDS concentrations that generally increase from east to west, with concentrations ranging from 300 to 2,600 milligrams per liter (mg/L) (BE 1995). TDS concentrations within the White Wolf

7 The federal Clean Water Act requires states to designate appropriate water uses to be protected and directs states to set water quality criteria based on these uses (United States Environmental Protection Agency [EPA] 2000a). Under section 303(d) of the Clean Water Act, states, territories, and authorized Indian tribes are required to submit lists to the EPA detailing water bodies for which existing pollution controls are insufficient to attain or maintain water quality standards. After submitting the list of "impaired waters" to the EPA, states must develop a TMDL plan to limit excess pollution. A TMDL is a number that represents the assimilative capacity of water for a particular pollutant, or the amount of a particular pollutant that the waterbody can receive without impacting its beneficial uses. TMDL plan implementation can be accomplished through revised permit requirements (for point source contaminants) and through implementation of Best Management Practices (EPA 1999).

Groundwater Basin range from 300 to 700 mg/L in the eastern two-thirds of the basin and 1,000 to 3,500 mg/L in the western one-third of the basin (BE 1995).

### 3.15.1.3 *Castaic Lake Water Agency*

CLWA is the wholesale water supplier for the Santa Clarita Valley. In addition, CLWA's Santa Clarita Water Division is one of four retail water purveyors within the Santa Clarita Valley. The other three retailers are Los Angeles County Waterworks District #36, Newhall County Water District and Valencia Water Company.

*Facilities*

CLWA receives SWP water through the terminus of the West Branch of the California Aqueduct at Castaic Lake. Surface water supplies (whether derived from local or imported water supplies) require treatment (filtration and disinfection) prior to distribution. SWP water from Castaic Lake is treated at the ESFP and RVWTP (both owned and operated by CLWA), and is distributed to the four water retailers through a system of pipelines.

The RVWTP is planned for future expansion from its current 30 mgd treatment capacity, to 60 mgd and eventually to 90 mgd as demands for treated water increase. This expansion was programmatically evaluated in CLWA's Capital Program Final EIR (CLWA 1988). In April 2003, CLWA approved an upgrade of treatment technology and a capacity expansion at the ESFP from 33.6 mgd to 56 mgd. The combined capacity of the two treatment plants currently is approximately 63.6 mgd. When the ESFP is expanded, the total treatment capacity will increase to about 86 mgd. Without the Project, CLWA's Water Supply Contract provides for a delivery maximum of 99 cfs for its 54,200 AF of Table A Amount. This delivery rate is approximately 65 mgd, or similar to the current treatment capacity, and would yield a maximum monthly delivery of approximately 6,000 AF. With the Project, CLWA's contractual delivery limit increases to 150 cfs (or approximately 98 mgd, yielding a maximum of approximately 9,000 AF per month) for the 95,200 AF of Table A Amount.

*Water Supply*

The current water supply for the Santa Clarita Valley is derived from both local and imported sources. The principal components of this supply are groundwater from the Alluvial Aquifer, groundwater from the Saugus Formation, and imported water from the SWP. A variety of future water sources (including local recycled[8] water, desalted ocean water, increased Saugus Formation production, conjunctive use of local or non-local groundwater basins, and other imported water sources) could be developed to supply future development planned for the CLWA service area.

CLWA completed an analysis of its water supply as part of the UWMP (CLWA 2000). Prior to that analysis, CLWA had determined that it could reliably depend on the SWP to deliver about half of its Table A Amount (about a 25,000 AF supply vs. 54,200 AF of Table A) in any year (CLWA 1996). The UWMP is scheduled to be updated in 2005.

8 Initial deliveries of recycled water commenced in 2003.

Table 3.15-6 summarizes water supplies available to meet demands in the CLWA service area in 1998, prior to the Project. SWP supplies identified in the table are based on results from DWR's SWP operations model, DWRSIM (discussed in section 3.15.2.2), with SWP water supplies allocated among Contractors under the Water Supply Contract provisions then in effect (i.e., based on the Monterey Amendment provisions). The table displays water supplies available under various hydrologic conditions.

**Table 3.15-6. 1998 Water Supplies for the CLWA Service Area**
(all values in AF)

| *Hydrologic Condition*[1] | SWP Supplies | | Existing Local Supplies | | *Total* |
|---|---|---|---|---|---|
| | *Table A*[2] | *SWP Flexible Storage*[3] | *Alluvial Aquifer* | *Saugus Formation* | |
| Average Year | 46,500 | 0 | 35,000 | 11,000 | **92,500** |
| Single Dry Year | 12,100 | 4,680 | 32,500 | 15,000 | **64,280** |
| Multiple Dry Year Period | 24,000 | 1,170 | 32,500 | 15,000 | **72,670** |

1. The average year supply is the average amount of water available based on DWRSIM model results over its entire period of hydrologic record. The single dry year supply is the supply available in the single year with the lowest total SWP deliveries based on DWRSIM model results (1977). Multiple dry year period supply is the average amount of water available over the four consecutive drought years of 1988 through 1991 based on DWRSIM model results. (See section 3.15.2.2).
2. Values based on CLWA's Table A Amount in 1998 (prior to the Project) of 54,200 AF, and percentages for Table A deliveries based on DWR's DWRSIM SWP operations model (discussed in section 3.15.2.2).
3. CLWA may withdraw up to about 4,680 AF of water from Castaic Lake as "flexible storage." It is assumed that CLWA would use this supply only in drier years, with the entire amount used in the one single dry year. For the multiple dry year, it is assumed that the entire amount would be used during the four-year period, or an annual average of 1,170 AF.

Table 3.15-7 summarizes existing (2002) water supplies available to meet demands in the CLWA service area, including the Project. SWP supplies are based on the data presented in DWR's SWP Delivery Reliability Report, with SWP water supplies allocated among Contractors under the Water Supply Contract provisions currently in effect (i.e., based on the Monterey Amendment provisions). The table displays water supplies available under various hydrologic conditions. In 2002, CLWA was able to store some of its allocated SWP Table A supply on a short-term basis (10 years or less) pursuant to a groundwater banking agreement with the Semitropic Water Storage District. CLWA may withdraw up to 21,600 AF within 10 years. Similar to 2002, in February 2004, CLWA was again able to store up to 35,000 AF of its allocated 2003 SWP Table A supply on a short-term basis (10 years or less) pursuant to a groundwater banking agreement with the Semitropic Water Storage District. CLWA may withdraw up to 31,500 AF within 10 years. In addition to the supplies identified in Tables 3.15-6 and 3.15-7, CLWA may obtain additional surface supplies on a limited basis when surplus water is available within the SWP system, along with various other SWP and non-SWP purchases and exchanges.

### Local Surface Water

The primary drainage course in the CLWA service area is the Santa Clara River. Principal tributaries to the Santa Clara River include creeks flowing from Mint, Bouquet, San Francisquito, Castaic Creek, Oak Spring, Sand, and Potrero canyons. Water flow in the stream

**Table 3.15-7. Existing Water Supplies for the CLWA Service Area**

(all values in AF)

| *Hydrologic Condition*[1] | SWP Supplies | | | Existing Local Supplies | | *Total* |
|---|---|---|---|---|---|---|
| | *Table A*[2] | *SWP Flexible Storage*[3] | *Semitropic Storage*[4] | *Alluvial Aquifer* | *Saugus Formation* | |
| Average Year | 68,300 | 0 | 0 | 35,000 | 11,000 | **114,300** |
| Single Dry Year | 18,600 | 4,680 | 7,200 | 32,500 | 15,000 | **77,980** |
| Multiple Dry Year Period | 34,300 | 1,170 | 5,400 | 32,500 | 15,000 | **88,370** |

1. The average year supply is the average amount of water available based on DWRSIM model results over its entire period of hydrologic record. The single dry year supply is the supply available in the single year with the lowest total SWP deliveries based on DWRSIM model results (1977). Multiple dry year period supply is the average amount of water available over the four consecutive drought years of 1988 through 1991 based on DWRSIM model results. (See section 3.15.2.2).
2. Values based on current Table A Amount of 95,200 AF (which includes the Project), and percentages for Table A deliveries from DWR's SWP Delivery Reliability Report (DWR 2003b).
3. CLWA may withdraw up to about 4,680 AF of water from Castaic Lake as "flexible storage." It is assumed that CLWA would use this supply only in drier years, with the entire amount used in the one single dry year. For the multiple dry year, it is assumed that the entire amount would be used during the four-year period, or an annual average of 1,170 AF.
4. In 2002, CLWA was able to store some if its allocated SWP Table A supply on a short-term basis (10 years or less) under a groundwater banking agreement with the Semitropic Water Storage District. Under this agreement, CLWA stored 24,000 AF of SWP water, and after consideration for losses, may withdraw up to 21,600 AF within 10 years. It is assumed that CLWA could expect to withdraw up to 1/3 of this amount in the single dry year, and the entire amount would be used during the four-year dry period. It is assumed that CLWA would only use this supply in drier years.

canyons and the upper Santa Clara River is ephemeral, and diminishes rapidly after most rainfall events. Surface water resources include the Santa Clara River and Castaic Lake.

Primary flood hazard areas occur in and along natural drainage channels, such as the Santa Clara River and its tributaries, and in areas where sheetflow may occur during high intensity rainfall (CLWA 1988, CLWA 1998a). CLWA does not utilize local surface water as a water supply, although landholders within the service area may use runoff from these natural drainages as a water supply.

GROUNDWATER

The existing local water supply in the CLWA service area is groundwater extracted from the Alluvial Aquifer and from the underlying Saugus Formation. Historically, groundwater has been the primary source of water in the Santa Clarita Valley. Since 1980, local groundwater supplies have been supplemented with imported water from the SWP.

Although the Alluvial Aquifer is the smaller of the two-aquifer systems as measured by storage capacity, most water wells within the CLWA service area are drilled into this aquifer. In his original assessment of the Alluvial Aquifer, Slade (1986) estimated the practical perennial yield of the Alluvial Aquifer to be 31,600 AFY to 32,600 AFY. The total annual groundwater production from the Alluvial Aquifer over the last 10 years (urban and agricultural production) has averaged approximately 35,000 AFY, about 10 percent higher than the "practical perennial yield" without any evidence of undesirable conditions that might be an indication of aquifer

overdraft (Slade 2002). Slade (2002) suggested that the primary reason that the Alluvial Aquifer has been able to supply groundwater in volumes that are in excess of its previously estimated perennial yield is due to the increase in imports of SWP water by CLWA. For example, most of the historical period on which Slade's original work was based predated the importation of SWP water. Based on discharge records published by the LARWQCB (2002), approximately half of this additional water is returned to the Alluvial Aquifer in the form of discharge from the two wastewater reclamation plants located along the Santa Clara River. Additionally, percolation of SWP water from various municipal and industrial uses (such as landscape irrigation) also contributed to recharge of the Alluvial Aquifer.

In this recent updated report on the groundwater basin, Slade (2002) identified the operational yield of the Alluvial Aquifer to be about 30,000 to 40,000 AF in normal weather years, and 30,000 to 35,000 AF in dry years. In updating his original (1986) analysis of the yield of the Alluvium, Slade recognized that the analytical methodology employed in his original work was no longer applicable, primarily due to a combination of stable groundwater levels and storage, and the progressive changes in the hydrology of the basin as a result of the increasing importation of supplemental water (from the SWP). In his updated analysis, Slade proposed that the concept of operational yield of the basin was more applicable to current conditions in the basin since it allows fluctuations in year-to-year yield in response to fluctuating hydrologic conditions, yet protects the renewability of the groundwater by retaining longer-term pumping within the basin's perennial yield on an average basis. The normal and dry-year ranges of basin yield were based by Slade on that operational yield concept.

Recharge amounts are highly variable depending on annual precipitation, with documented annual water level recoveries of 70 feet or more during wet years that follow dry periods. Multi-year dry periods have in the past resulted in water level decreases of as much as 100 feet from the beginning to the end of the multi-year drought period, particularly in Soledad Canyon. However, groundwater levels have remained very stable over time (and near the ground surface) throughout the western part of the basin, generally west of Bouquet Canyon. This relative stability occurs because the regional discharge zone for the valley's groundwater resources is the alluvium west of Interstate 5. In this area, the Saugus Formation discharges to the alluvium, which in turn discharges to the Santa Clara River. The discharge zone is present in this area because of the east-west movement of groundwater and the bedrock materials that form the western margin of the basin aquifer systems at Blue Cut (just to the west of the Los Angeles County / Ventura County line). The shallow and stable nature of the groundwater levels in this area are further supported by a continual supply of recharge water from the treatment plant discharges described above.

From 1980 to 2002, groundwater extraction from the Alluvial Aquifer for urban uses ranged from approximately 8,700 to 27,200 AFY, while total extraction for all uses ranged between 20,300 and 43,400 AFY. Average extractions from the Alluvial Aquifer during this same period were approximately 17,500 AFY for urban uses and 30,400 AFY for all uses (SCVWP 2002). The latter remains well within all historical estimates of the yield of the Alluvial Aquifer. The use of one well in the Alluvial Aquifer has been suspended due to the detection of perchlorate. (Groundwater quality in the Alluvial Aquifer is discussed in more detail under the subheading Groundwater Quality.)

The Saugus Formation contains much greater quantities of groundwater than the Alluvial Aquifer. In his original assessment of the Saugus Formation, Slade (1988) estimated that approximately 1.41 million AF of potentially useable groundwater was present from depths of 500 to 2,500 feet in the Saugus Formation. More recent information on the thickness of the alluvium and the degree of potential drawdown interference between adjacent Saugus Formation and Alluvial Aquifer wells has supported a re-calculation of groundwater in storage in the Saugus Formation to approximately 1.65 million AF (Slade 2002).

The principal source of recharge to the Saugus Formation is precipitation on exposed outcrops and direct infiltration from the overlying alluvium. In his initial assessment of the Saugus Formation, Slade (1988) estimated the combined potential recharge to the Saugus Formation from these two sources to be from 20,000 to 22,000 AFY in wet periods, and from 11,00 to 13,000 AFY in dry periods. The Saugus Formation has supplied about 7,500 to 15,000 AF in normal weather years, and 11,000 to 15,000 AF in dry years (CLWA 2000). No long-term continuous or permanent decline in either water levels or the amount of groundwater in storage has occurred under this historical range of pumping (Slade, 2002). Based on the amount of water in storage and the historic aquifer performance, Slade (2002) identified that production from the Saugus Formation for dry period water supply could be increased from 15,000 to 20,000 AFY, and ultimately to 35,000 AFY if dry conditions continue. The increase to 35,000 AFY would be temporary and would need to return to, or be reduced below, the historical range of 7,500 to 15,000 AFY once rainfall patterns returned to normal in order to recharge, or replenish, storage and avoid long-term adverse effects to the aquifer.

From 1980 to 2002, groundwater extractions from the Saugus Formation for urban uses ranged between approximately 2,700 and 14,400 AFY, while total extraction for all uses ranged between about 3,700 and 14,900 AFY. Average extraction from the Saugus Formation during this same period has been approximately 6,200 AFY for urban uses and 6,800 AFY for all uses (SCVWP 2002); these values remain well within all historical estimates of the yield or recharge potential of the Saugus Formation. The use of four wells in the Saugus Formation has been suspended due to the detection of perchlorate. (Groundwater quality in the Saugus Formation is discussed in more detail under the subheading Groundwater Quality.)

There are numerous wells in the Saugus Formation, other than the wells that were voluntarily shut down due to perchlorate contamination. Additionally, other Saugus wells are planned for construction, including those included in CLWA's Capital Improvements Program. If operated continuously during the year, the wells not subject to perchlorate contamination have the capability to produce approximately 21,000 AFY (personal communication, L. Takaichi 2004). However, a more realistic production capability is 15,000 AFY due to periodic shutdown for maintenance, monitoring, or storage limitations (personal communication, L. Takaichi 2004). The current groundwater production capability from the Saugus Formation is estimated to be 5,000 AFY during normal years but could reach 15,000 AFY during dry periods or other periods of need (personal communication, L. Takaichi 2004). These capabilities will increase as additional production wells in the Saugus Formation are completed and a response action to perchlorate contamination is implemented.

With regard to the impacts of perchlorate on the water supply capacity of several wells as noted above, field studies and groundwater modeling activities are in progress to evaluate how best

to hydraulically contain the portion of the aquifer system where production wells have been shut down, while simultaneously preventing perchlorate movement to currently unimpacted areas. The field studies have included the installation and sampling of monitoring wells at multiple depths and locations on and around the Whittaker-Bermite site, the most likely source of perchlorate; water level monitoring in these wells; aquifer testing of two unimpacted water supply wells; and groundwater velocity testing in alluvial monitoring wells located between the site and the Santa Clara River. These studies have helped the Purveyors and the Whittaker Corporation further refine the current understanding of groundwater flow patterns in specific areas on and near the site (such as along the Holser Fault). This information has been incorporated into a regional groundwater flow model that has been developed by the Purveyors and whose calibration and construction was recently reviewed and approved by the DTSC. The model is being used to identify a pumping scheme that would meet the objectives of restoring the lost water supply from the impacted wells (with wellhead treatment) while simultaneously containing perchlorate and hydraulically limiting its movement downgradient to unimpacted wells and other portions of the aquifer system where new water supply wells might be constructed. The modeling analysis accounts not only for the pumping of impacted wells, but also (a) the UWMP's pumping plan for unimpacted wells throughout the Santa Clarita Valley and (b) the significant year-to-year variation in local hydrology (especially groundwater recharge) that occurs in the Valley (CH2MHill 2004). The modeling simulations will be used to guide selection of a final pumping plan for the impacted Alluvial Aquifer well and the impacted Saugus Formation wells. The selection of a final pumping plan will be made jointly by the Purveyors and the Whittaker Corporation, with regulatory oversight and permitting performed by CA DHS with technical support from DTSC. (Groundwater quality and perchlorate are discussed in more detail under the subheading Groundwater Quality.)

IMPORTED WATER

CLWA provides imported water supplies via the SWP to the CLWA service area. CLWA facilities and supplies of SWP water are described above.

SWP deliveries to CLWA from 1990 through 2002 are provided in Table 3.15-8. SWP supplies supplement local water sources and are used to meet the municipal and industrial demand of the region. From 1990 to 1999 (prior to implementation of the Project), CLWA's use of its SWP supply averaged approximately 18,000 AF. This low level of SWP delivery (relative to CLWA's Table A Amount) is a reflection of generally low demand in the CLWA service area for this water during this period and is not due to limited SWP supplies. With the exception of 1991, during 1990 to 1999 CLWA received adequate SWP supplies to meet its demands. As is shown on Table 3.15-8, SWP deliveries to CLWA generally have increased over the past decade because demands within the service area have risen during this time.

TOTAL SUPPLY

Table 3.15-8 shows total water deliveries in the CLWA service area from 1990 through 2002. These include deliveries by the four municipal water purveyors, along with groundwater pumped by agriculture and miscellaneous uses. Agriculture and miscellaneous uses include irrigated agriculture, landscape irrigation, golf course irrigation, and other miscellaneous uses within the service area.

**Table 3.15-8. Summary of Annual SWP and Local Groundwater Use within the CLWA Service Area, 1990 to 2002**

| *Year* | *SWP Table A Amount (AF)* | *SWP Allocation[1] (Percent)* | *SWP Deliveries (AF)* | *Local Groundwater Deliveries[2] (AF)* | *Agriculture and Miscellaneous Uses[3] (AF)* | *Total (AF)* |
|---|---|---|---|---|---|---|
| 1990 | 41,500 | 100 | 21,600 | 21,500 | 11,280 | 54,380 |
| 1991 | 54,200 | 30 | 7,970 | 31,800 | 10,280 | 50,050 |
| 1992 | 54,200 | 45 | 14,900 | 27,300 | 12,150 | 54,350 |
| 1993 | 54,200 | 100 | 13,840 | 30,000 | 11,220 | 55,060 |
| 1994 | 54,200 | 53 | 14,700 | 31,600 | 13,870 | 60,170 |
| 1995 | 54,200 | 100 | 17,000 | 28,700 | 14,350 | 60,050 |
| 1996 | 54,200 | 100 | 18,870 | 32,100 | 15,350 | 66,320 |
| 1997 | 54,200 | 100 | 23,220 | 32,000 | 16,390 | 71,610 |
| 1998 | 54,200 | 100 | 20,270 | 28,600 | 13,610 | 62,480 |
| 1999 | 54,200 | 100 | 27,300 | 30,000 | 17,140 | 74,440 |
| 2000 | 95,200 | 100 | 32,580 | 28,400 | 15,320 | 76,300 |
| 2001 | 95,200 | 39 | 35,370 | 25,320 | 16,090 | 76,780 |
| 2002 | 95,200 | 70 | 41,770 | 26,460 | 16,810 | 85,040 |

*Source:* SCVWP 2003.

1. SWP allocation (i.e. the percent of Table A Amount that each Contractor could have received based on that year's supply availability and Contractor requests), as determined by DWR for the year. The values shown are M&I Table A allocation percentages. In 1991, the Devil's Den Water District permanently transferred 12,700 AF of agricultural Table A Amount to CLWA. For years prior to implementation of the Monterey Amendment in 1996, agricultural Table A allocations were as follows: 0 percent in 1991; 45 percent in 1992; 100 percent in 1993; 53 percent in 1994; and 100 percent in 1995.
2. Groundwater deliveries by municipal water purveyors within the CLWA service area.
3. Includes groundwater pumped by, and SWP water delivered to, agricultural and miscellaneous uses within the CLWA service area. SWP deliveries to agricultural and miscellaneous uses within the CLWA service area occurred from 1992 to 2000, with a maximum of approximately 1,070 AF delivered in 1997.

*Water Demand*

In 1998, the total water demand within the CLWA service area in 2010 was projected to be approximately 106,300 AF. Table 3.15-9 provides CLWA's projected total future water demands in years of average local precipitation based on the UWMP, the most recent future water demand projections by CLWA. CLWA's demands vary from year-to-year depending on local hydrologic and meteorologic conditions, with demands generally increasing in years of below average local precipitation and decreasing in years of above average local precipitation. Based on various planning factors, CLWA's average year demand is expected to increase to approximately 75,100 AF in 2005 and 102,500 AF by 2020, or approximately 1,370 AFY (CLWA 2000). This is consistent with the annual average increase in CLWA's SWP deliveries from 1990 to 2001 of approximately 1,150 AFY (SCVWP 2002).

**Table 3.15-9. CLWA's Projected Total Water Demand in Average Hydrologic Years**
(AFY; reductions in parenthesis)

| | 2005 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| M&I | 66,600 | 77,700 | 90,900 | 106,000 |
| Other Demand[1] | 15,100 | 12,400 | 9,800 | 7,100 |
| *Subtotal* | *81,700* | *90,100* | *100,700* | *113,100* |
| Projected Conservation | (6,600) | (7,700) | (9,100) | (10,600) |
| **Total** | **75,100** | **82,400** | **91,600** | **102,500** |

*Source:* CLWA 2000.
1. Includes irrigated agriculture and miscellaneous uses.

Because growth has exceeded that projected when the UWMP was prepared in 2000, actual demand exceeds projected demand. The UWMP is scheduled to be updated in 2005. This EIR uses the best available data. New UWMP data is not available at this time.

In 2001, CLWA signed the Memorandum of Understanding Regarding Urban Water Conservation in California (MOU) on behalf of the CLWA service area, as recommended in the UWMP. By signing the MOU, CLWA became a member of the California Urban Water Conservation Council (CUWCC) and pledged to implement all cost-effective Best Management Practices (BMPs) for water conservation. CLWA has implemented 11 of the 14 BMPs recommended by CUWCC. CLWA has estimated that conservation measures within the service area can reduce total water demands by 6,600 AF in 2005 and up to 10,600 AF in 2020, or about 10 percent of demand.

*Water Quality*

With regard to water quality, the main regulatory driver for CLWA is the Safe Drinking Water Act[9], because CLWA, as a wholesale water purveyor, must deliver water that meets the applicable drinking water standards.

EXISTING WATER QUALITY

Existing water quality conditions for urban water uses in the CLWA service area are documented in the Santa Clarita Valley 2002 Water Quality Report (CLWA 2002). That report provides the cumulative results of thousands of water quality tests performed in the Santa Clarita Valley area on CLWA's and the local purveyors' water supplies. Table 3.15-10 provides basic water quality data for CLWA's drinking water supplies, which includes test results from both SWP water and groundwater.

9 The Safe Drinking Water Act is intended to protect public health by regulating the nation's public drinking water supply, and requires a variety of actions to protect drinking water and its sources. The Act authorizes the EPA to set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants that may be found in drinking water.

**Table 3.15-10. CLWA Drinking Water Quality Summary**

| *Constituent*[1] | *MCL*[2] | *Typical Value* | *Range* |
|---|---|---|---|
| Turbidity, nephelometric turbidity Unit (NTU) | 5 | 0.08 | 0.05-0.40 |
| Chloride[3], mg/L | 250 | 86 | 65-112 |
| Nitrate (as $NO_3$), mg/L | 45 | 2-2.8 | 2.0-2.8 |
| Fluoride, mg/L | 2 | 0.15 | 0.12-0.18 |
| Trihalomethanes (THMs) | 100 | 86 | 65-112 |
| Haloacetic Acids (HAA5) | 60 | 34 | 16-81 |
| Coliform, percent positive samples | 5 | 0 | 0-2 |
| Sulfates, mg/L | 250 | 52 | 38-64 |
| TDS, mg/L | 500 | 314 | -- |
| pH | None | 7.86 | 7.5-8.2 |

*Source:* CLWA 2002b.
1. Unless stated otherwise, all tests were run in 2001.
2. A MCL (Maximum Contaminant Level) is the maximum permissible level of a contaminant in drinking water that is delivered to any user of a public water system.
3. The chloride standard is a Secondary Standard. Secondary Standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. States may choose to adopt them as enforceable standards, however.

LOCAL SURFACE WATER QUALITY

In accordance with the Porter-Cologne Act and the Clean Water Act, the LARWQCB developed the Water Quality Control Plan for the Coastal Watersheds of Los Angeles and Ventura Counties (Basin Plan), as amended (LARWQCB 1994). The Basin Plan addresses five constituents of concern that are relevant for inland surface water and groundwater (TDS, sulfate, chloride, boron, and nitrogen) and considers local hydrology, land use, population, sensitive environmental resources, and established water quality objectives for each of the watersheds, including the Santa Clara River. New and proposed water quality objectives for the Santa Clara River watershed have either been established or are currently undergoing discussion for future approval and/or consideration. Within the Santa Clara River watershed, chlorides have been prioritized for further study, with higher priority given to nutrients. Other constituents are currently (2003) not prioritized.

On February 4, 2003, the SWRCB adopted the 2002 Clean Water Act Section 303(d) List of Water Quality Limited Segments for Surface Waters in California (referred to herein as "Section 303(d) List") (SWRCB 2003b). This list identifies water quality-limited water bodies and pollutants of concern for which a TMDL must be developed. Reach 3[10] of the Santa Clara River (Freeman Diversion to A Street) was listed as impaired for ammonia, chloride, and TDS. Reach 7 (Blue Cut near the Los Angeles/Ventura County line to West Pier Hwy 99 Bridge) was listed as

10 The Santa Clara River is divided into nine reaches for management purposes. Reach 1 begins at the Santa Clara River Estuary at the Pacific Ocean. Reach numbers increase upstream.

impaired for chloride, high coliform count, nitrite and nitrate, and delisted for ammonia. Reach 8 (West Pier Hwy 99 to Bouquet Canyon Road) was listed as impaired for chloride and for high coliform count. Lastly, Reach 9 (Bouquet Canyon Road to above Lang Gaging Station) was listed as impaired for high coliform count.

**Chlorides** – In recent years, high concentrations of chloride have been measured in waters of the Santa Clara River watershed. These concentrations are primarily due to various types of loading during beneficial water uses, including agricultural uses (irrigation and leaching); commercial uses; domestic uses; and water treatment (e.g., water softeners) (LACSD 2002a). In addition to loading from urban runoff, imported water in certain year types, and the discharge of treated wastewater, naturally occurring chloride concentrations contribute to excessive chloride concentrations in Santa Clarita Valley groundwater (LARWQCB 1999b). The identification of excessive chloride concentrations resulted in the addition of several reaches of the Santa Clara River in the Section 303(d) List, as identified above. Table 3.15-11 provides a timeline summary of the regulatory actions taken to regulate chloride loading within the Santa Clara River.

**Table 3.15-11. Regulatory Timeline for Chloride**

| *Time* | *Action* |
|---|---|
| January 1997 | LARWQCB adopts a Chloride Policy, which consists of Resolution No. 97-02: Amendment to the California Regional Water Quality Control Plan for the Los Angeles Region, to Incorporate a Policy for Addressing Levels of Chloride in Discharges of Wastewaters. |
| Fiscal Year 1997/1998 | Santa Clara River Reaches 3, 7 and 8 are added to the Section 303(d) List for chloride impairment, and TMDL monitoring commences. |
| October 2002 | LARWQCB amended the 1994 Basin Plan to incorporate a TMDL for chloride for the upper Santa Clara River, establishing the 100 mg/L surface water quality objective for Reaches 7 and 8 (SWRCB 2002). |
| February 2003 | SWRCB remanded the chloride TMDL back to the LARWQCB to consider sequentially phasing TMDL implementation tasks, extending the interim limits, and reevaluation of the chloride objective itself (SWRCB 2003a). |
| March 2003 | LACSD adopts an ordinance that prohibits the installation and use of new self-regenerating water softeners in the Santa Clarita Valley to help lessen the chloride loading in the region (LACSD 2002a). |
| May 2003 | EPA is developing chloride TMDLs for Reaches 3, 7 and 8 of the Santa Clara River, in the event that the LARWQCB does not adopt it's chloride TMDL by June 2003 (EPA 2003). |
| July 2003 | The LARWQCB adopted the chloride TMDL in light of the Remand Resolution, and revised the Basin Plan to incorporate the chloride TMDL. |

In October 2002, the LARWQCB amended the 1994 Basin Plan to incorporate a TMDL for chloride for the upper Santa Clara River, establishing a 100 mg/L surface water quality objective for Reaches 7 and 8 to protect the agricultural beneficial use of the river (SWRCB 2002). The TMDL is intended to reduce the sources in the upper Santa Clara River by reducing the sources of chloride discharged from households and industries and, if necessary, by constructing a chloride removal system to treat water reclamation plant effluent before discharge to the Santa Clara River. On February 19, 2003, the SWRCB remanded the chloride TMDL back to the LARWQCB to consider sequentially phasing TMDL implementation tasks,

extending the interim limits, and reevaluation of the chloride objective itself (SWRCB 2003a). The LARWQCB adopted the 100 mg/L chloride TMDL, and incorporated it into the Basin Plan on July 10, 2003 (LARWQCB 2003a). Because the State was not able to complete adoption of a chloride TMDL for Reach 3 (80 mg/L) of the Santa Clara River by the June 22, 2003 deadline, EPA is establishing the TMDL for Reach 3 to fulfill its legal obligations (EPA 2003). The EPA is also establishing chloride TMDLs for Reaches 5 and 6[11] (100 mg/L) at this time, at the request of the LARWQCB.

The Los Angeles County Sanitation Districts (LACSD) have compiled the Santa Clarita Valley Joint Sewerage System Chloride Source Report, a detailed and comprehensive study of the sources of chloride loading in the Santa Clarita Valley (LACSD 2002a). That study identified that residential water use, primarily from self-regenerating water softeners, greatly contributes to the chloride loading. Based on the results of that study, the LACSD adopted an ordinance that prohibits the installation and use of new self-regenerating water softeners in the Santa Clarita Valley. This ordinance took effect in March 2003.

**Nitrogen** –The LARWQCB adopted a nutrient TMDL in late 2003 for the upper Santa Clara River that addresses the Section 303(d) List for nitrate plus nitrite impairment (LARWQCB 2003b). The TMDL limits nitrate ($NO_3$), nitrite ($NO_2$), ammonia ($NH_3$), and total nitrogen (N). Principal sources of nitrogen to a watershed typically include discharges from water reclamation plants and runoff from agricultural activities. Elevated nitrogen concentrations (ammonia, nitrate, and nitrite) can cause impairments in warm water fish and wildlife habitat, along with contributing to eutrophic effects such as algae growth and low dissolved oxygen.

**Other Impairments** – Reaches 7, 8, and 9 of the Santa Clara River are listed as impaired on the Section 303(d) List for fecal coliform. Sources of coliform can include discharges from water reclamation plants, urban stormwater runoff, and septic tanks. A coliform TMDL for the upper Santa Clara River is scheduled for completion in 2006.

Typical data ranges for the Santa Clara River and Basin Plan objectives are provided in Table 3.15-12. Water quality in the Santa Clara River is considered generally impaired due to high concentrations of chlorides (LARWQCB 1999b). Much of the water present in the Santa Clara River west of Bouquet Canyon Road is a result of discharges from current wastewater treatment and reclamation plants. Beneficial uses for Pyramid and Castaic lakes as designated by the LARWQCB were presented in the discussion of the SWP facilities.

IMPORTED WATER QUALITY

Raw water from Castaic Lake delivered to the ESFP and RVWTP is generally of high quality. CLWA produces water that meets drinking water standards set by the EPA and the California Department of Health Services (CA DHS) (SCVWP 2003). A summary of the water quality data for 1990 to 2001 for Castaic Lake can be found in Table 3.15-4, in the discussion of SWP water quality.

11 The 303 (d) list identifies the impaired Reaches as 3, 7, and 8. Reaches 7 and 8, however, correspond to those identified as Reaches 5 and 6 in the Basin Plan and in the chloride TMDL. EPA is using the designations of Reaches 5 and 6 in the TMDL to correspond to the Basin Plan (EPA 2003).

Table 3.15-12. Water Quality Summary for the Santa Clara River

| Constituent | Applicable Objective/Criteria | Typical Data Ranges Resulting in Impairment | 303(d) Listed Waters/ Santa Clara River Reaches |
|---|---|---|---|
| Ammonia[1] | 0.53-2.7 mg/L | ND-4.9 mg/L (mean of 1.4 ± 1.3) | Reaches 3, 7, and 8 |
| Chloride | 80-100 mg/L | 10-138 mg/L (mean of 105 ± 21) | Reaches 3, 7, 8, and 9 |
| Nitrate + Nitrite | ≤ 10 mg/L | 0.3-15.4 mg/L (mean of 5.7 ± 2.4) | Reach 8 |
| Organic enrichment/low Dissolved Oxygen | 5.0-7.0 mg/L[2] | 0.8-11.0 mg/L (mean of 7.7 ± 2.5) | Reaches 8 and 9 |
| Coliform | 100-400 MPN/100ml[3] | 20-24000 MPN/100ml | Estuary and Reach 8 |
| Sulfate | 150 mg/L | ND | Reach 9 |

*Source:* LARWQCB 2001.
*Abbreviations:* mg/L = milligrams per liter; MPN = most probable number; ND = none detected; ml = milliliter.

1. Basin Plan numeric objective varies depending on pH and temperature. The general range is 0.53-2.7 mg/L of total ammonia (at average pH and temp.) in waters designated as warm to protect against chronic toxicity and 2.3-28.0 mg/L to protect against acute toxicity.
2. Annual Basin Plan numeric objective mean greater than 7.0 mg/L and no single sample less than 5.0 mg/L.
3. Inland objective: fecal coliform not to exceed log mean of 200 most probable number (MPN)/100 milliliters (ml) in 30-day period and not more than 10 percent of samples exceed 400 MPS/100ml. Beach objective: total coliform not to exceed 1,000 MPN/100 ml in more than 20% of samples in 30 days and not more than 10,000 MPN/100 ml at any time.

### GROUNDWATER QUALITY

Groundwater monitoring in Alluvial Aquifer wells has shown chloride concentrations to be below the Basin Plan groundwater chloride objective of 150 mg/L, and nitrate concentrations to be below the 10 mg/L Basin Plan groundwater objective (LADRP 2003). The 1994 Basin Plan includes water quality objectives for bacteria, chemical constituents and radioactivity, mineral quality, nitrogen (nitrate, nitrite), taste and odor, TDS, sulfate, chloride and boron objectives for groundwater. All Basin Plan groundwater objectives are designed to protect groundwater for municipal drinking water purposes.

The groundwater quality of the Alluvial Aquifer is generally acceptable quality for domestic use without treatment, although Alluvial Aquifer water produced for domestic use is disinfected by the domestic water purveyors prior to delivery. The groundwater is generally of calcium bicarbonate, calcium sulfate or calcium-bicarbonate sulfate character, depending on location within the aquifer. TDS concentrations in the Alluvial Aquifer generally increase in concentration from approximately 550 to 610 mg/L in the eastern portion of the aquifer to approximately 660 to 710

mg/L in the western portion of the aquifer (Slade 2002). Other inorganic constituents follow similar trends.

The groundwater quality of the Saugus Formation is generally acceptable for domestic use without treatment, although Saugus Formation water produced for domestic use is disinfected by the domestic water purveyors prior to delivery. The groundwater is generally of calcium bicarbonate or calcium-magnesium sulfate character. Water quality generally deteriorates near the perimeter or base of the aquifer (e.g., near the geologic contact between the Saugus Formation and the underlying Pico Formation). Calculations of TDS concentrations in the Saugus Formation indicate levels greater than 800 ppm for both shallow (500 to 1,000 feet) and deep (2,000 to 2,500 feet) aquifers within the Saugus Formation (Slade 1988).

Groundwater produced by the water purveyors in the CLWA service area consistently meets drinking water standards set by the EPA and the CA DHS. In 2002, the local purveyors conducted additional water quality monitoring for constituents that lack drinking water standards in compliance with the federal and state Unregulated Contaminant Monitoring Rule (UCMR) regulations (SCVWP 2003).

**Perchlorate** – As of April 2003, according to the CA DHS, over 173 surface water and groundwater sampling points within the Los Angeles Region have detected perchlorate, ranging from 4 micrograms per liter (μg/L) to 159 μg/L (LARWQCB 2003). Within the CLWA service area, perchlorate has been a concern with respect to the groundwater quality since it was detected in four production wells in the eastern part of the Saugus Formation in 1997. Perchlorate is a chemical associated with many industrial applications, but primarily as a component of rocket fuel. Although there are neither Federal nor State limits/standards for perchlorate in drinking water, it was placed on the EPA's Drinking Water Contaminant Candidate List in 1998. In a further step to establish standards, the EPA required drinking water monitoring for perchlorate under the UCMR in 1999.

On December 6, 2002, the California Office of Environmental Health Hazard Assessment (OEHHA) proposed a public health goal, in the range of 2 to 6 parts per billion (ppb), for the amount of perchlorate present in drinking water (LADRP 2003a). Both the federal and state governments require monitoring for perchlorate and have recommendations for potable water uses of water sources exceeding 18 μg/L. The CA DHS has lowered the action level for perchlorate in drinking water from 18 ppb to 4 ppb (CA DHS 2002). In addition to the OEHHA's proposed public health goal, the CA DHS is required to adopt a primary drinking water standard for perchlorate by January 1, 2004 (LADRP 2003a). A Maximum Contaminant Level (MCL)[12] for perchlorate is not expected until 2004 (SCVWP 2003).

In 1997, perchlorate was detected in two production wells in the Saugus Formation, both of which are near the Whittaker-Bermite property, a former weapons manufacturing and testing site. These two wells had perchlorate levels above the 18 μg/L recommendation level and the use of these wells has been suspended. Two other production wells in the Saugus Formation

12 A MCL is the maximum permissible level of a contaminant in drinking water which is delivered to any user of a public water system. MCLs ensure that drinking water does not pose either a short-term or long-term health risk. MCLs are specified by the EPA, as authorized by the Safe Drinking Water Act.

have shown detectable levels of perchlorate below 18 μg/L and the use of these wells has been suspended. Due to the number and distribution of wells in the Santa Clarita Valley, the need to suspend use of these wells (the combined capacity of the four wells is 8,000 gallons/minute) has not had a substantial effect on overall water supply. In 2002, perchlorate was detected in one Alluvial Aquifer production well located near the Whittaker-Bermite property. That well tested positive for perchlorate at a level of 5.9 μg/L (SCVWP 2003). All five perchlorate-impacted wells have been removed from active water supply service (SCVWP 2003). The local purveyors are continuing to test for perchlorate in all of their active wells, and are developing a plan for a water treatment process to return the impacted wells to service.

The development and implementation of a cleanup plan for the Whittaker-Bermite site and the impacted groundwater is being coordinated among CLWA, the local purveyors, the City of Santa Clarita, DTSC, and the U.S. Army Corps of Engineers. In February 2003, the DTSC and the impacted local purveyors entered into an agreement in which DTSC will provide review and oversight of the response activities being undertaken by the impacted local purveyors related to the detection of perchlorate in the five impacted wells (SCVWP 2003). Under the scope of work of that agreement, the local purveyors will prepare: (a) well characterization reports; (b) a health-based risk assessment; (c) a regional groundwater flow model; and (d) a treatment technology evaluation report (SCVWP 2003). Several treatment technologies for the removal of perchlorate from water are currently available. As discussed above under the sub-heading of Water Supply, these various studies are underway.

In 2002, the EPA implemented the new Disinfectants and Disinfection Byproducts Rule, which in part, establishes a new MCL of 80 μg/L for total trihalomethanes (TTHM). TTHMs are a byproduct that is created when free chlorine is used as a means for disinfection. CLWA and the local purveyors are investigating alternative methods of disinfection to be able to maintain compliance with the new rule and future regulations relating to disinfection byproducts (SCVWP 2003).

Similarly, the EPA has revised the MCL for arsenic from 50 μg/L to 10 μg/L. Compliance with the federal standard is not required until 2006. However, in March of 2003, the OEHHA proposed a draft Public Health Goal for arsenic at 4 parts per trillion (ppt) (SCVWP 2003). CA DHS is required to establish a new MCL for arsenic by June 30, 2004. Historically, naturally occurring arsenic concentrations less than 5 μg/L have been detected in a few local groundwater supplies and less than 3 μg/L in SWP water supplies. Most groundwater wells in the Santa Clarita Valley have non-detectable concentrations of arsenic.

## 3.15.2 Impacts of the Project

### *3.15.2.1 Significance Criteria*

The criteria listed below are based on Appendix G of the State CEQA Guidelines. The Project would have a significant impact on water resources if it would:

- violate (or cause the violation of) any water quality standards or waste discharge requirement;

- substantially deplete groundwater supplies or interfere substantially with naturally occurring groundwater recharge;
- substantially alter the existing drainage pattern of the site or area, including the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site;
- substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site;
- create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff;
- otherwise substantially degrade water quality;
- place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map;
- place within a 100-year flood hazard area structures which would impede or redirect flood flows;
- expose people or structures to significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam; or,
- cause inundation by seiche, tsunami, or mudflow.

### 3.15.2.2 *Environmental Impacts*

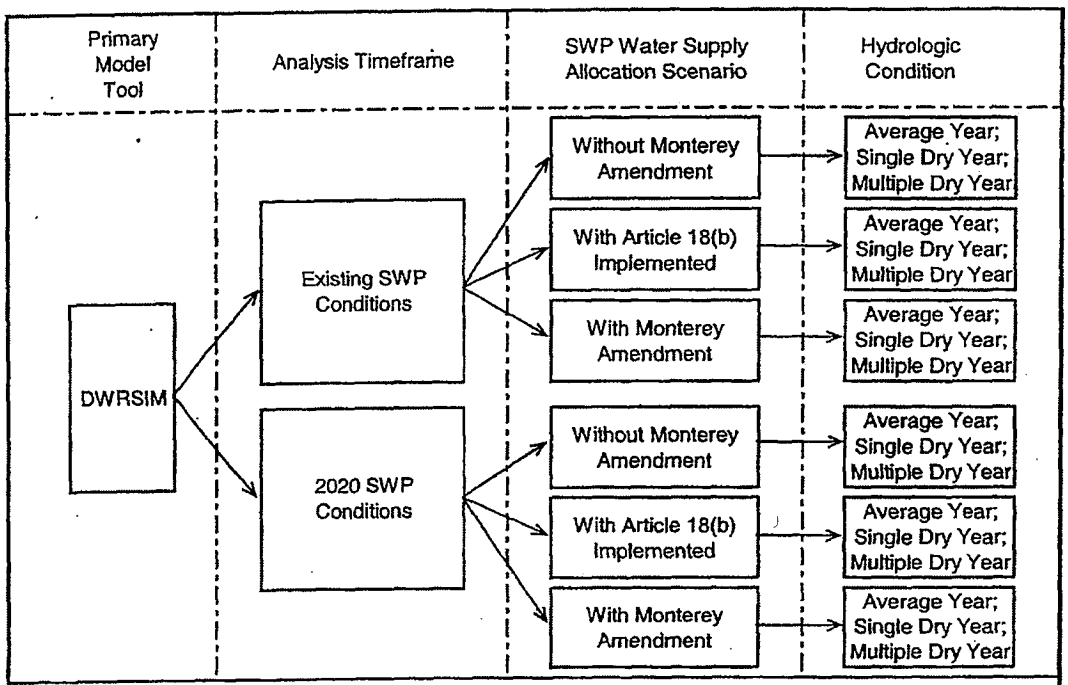
*Analysis Methodology*

The analysis of direct impacts focuses on the Project's potential to affect water quality, groundwater supplies, and surface water supplies associated with the SWP, WRMWSD, and CLWA. Alterations in elevation, depth, and surface area of water bodies, while not necessarily an impact to hydrology, can affect other resources such as aesthetics, biological resources, cultural resources, and geology and soils. These potential effects are considered within the impact discussions for the specific resources affected.

Figure 3.15-5 provides an overview of the SWP water supply analysis. The components shown in this figure, including the Primary Model Tool, Analysis Timeframe, SWP Water Supply Allocation Scenarios, and Hydrologic Conditions are described directly below. Following these discussions is a description of the general methodology followed in the analyses. Appendix D provides additional detail on the water supply analysis methodology and results.

PRIMARY MODEL TOOL AND ANALYSIS TIMEFRAME

The amount of SWP water supply that would be available for use by CLWA given the transfer of the Project's 41,000 AF of Table A Amount was assessed using results from DWR's planning




**Definitions:**

DWRSIM - DWR's SWP operations model. DWRSIM calculates the amount of water the SWP could deliver to Contractors in each month over a 73-year period of hydrologic record, based on a given set of facilities and operating constraints and for a given level of Contractor demand. (DWRSIM studies used were conducted by DWR in 1998 for CALFED Bay-Delta Program EIS/EIR [CALFED 2000].)

Existing SWP Conditions - A timeframe for anlaysis in the DWRSIM study. The existing condition study assumes the use of then-existing (1998) SWP facilities and operating constraints, along with then-current estimates of Contractor demands and upstream land and water use. (DWRSIM study 1995D06E-CALFED-771)

2020 SWP Conditions - A timeframe for analysis in the DWRSIM study. The 2020 condition study assumes the use of then-existing (1998) SWP facilities and operating constrains, along with estimated future (2020) Contractor demands upstream land and water use. (DWRSIM study 2020D09C-CALFED-786)

Without Monterey Amendment (Initial agricultural reduction in allocations) - Allocation of available SWP supplies based on the original terms of the Water Supply Contracts.

With Article 18(b) Implemented (Proportionate reduction in Table A Amounts) - Proportionate reduction in Contractor's Table A Amounts and allocation of available SWP supplies based on the original terms of the Water Supply Contracts, assuming DWR implemented Article 18(b) (i.e., the permanent shortage provision).

With Monterey Amendment (Proportionate reduction in allocations) - Allocation of available SWP supplies based on the terms of the Monterey Amendment to the Water Supply Contracts.

Average Year - The average quantity of supply available, based on the 73 years of DWRSIM model results.

Single Dry Year - Supply available in the single year with the lowest total SWP deliveries, based on the DWRSIM model results (1977). The single dry year supply is considered to be the worst-case scenario, with a probability of occurrence of once in 73 years, or about 1.4 percent of the time.

Multiple Dry Year - Average supply available over the four consecutive drought years of 1988 through 1991, based on the DWRSIM model results.

**Figure 3.15-5. Water Supply Analysis Overview**

model, DWRSIM. The two model studies used in this analysis simulate SWP and CVP operations and were conducted by DWR in 1998 for the CALFED Bay-Delta Program EIS/EIR (CALFED 2000). One of the model's inputs is a time series of monthly runoff based on historic hydrologic data from 1922 through 1994 (73 years), with that hydrologic data adjusted to reflect a current or future level of upstream land and water use. DWRSIM estimates the amount of water the SWP could deliver to Contractors in each month over the 73 years of operation, for a given set of facilities and operating constraints and for a given level of Contractor demand. The results are interpreted as the capability of the SWP to meet the assumed SWP demand, over a range of hydrologic conditions, for that assumed set of physical facilities and operating constraints.

The two DWRSIM studies both assume the use of SWP facilities and operating constraints that were present in 1998. One study uses 1998 estimates of existing Contractor demands and upstream land and water use, and the other uses 2020 projections for both Contractor demands and upstream land and water use.

These model runs provide the best estimates of SWP supply reliability that were available in 1998, and are consistent with the 1998 environmental setting used in this EIR. Since these studies were conducted, the modeling tool DWR uses to simulate operations has evolved (first to CALSIM I, and more recently to CALSIM II). However, while the modeling tool itself has changed, the criteria used in the models to simulate SWP operations have not significantly changed. While DWR has completed a more recent assessment of SWP reliability in its SWP Delivery Reliability Report using CALSIM II, the results of these new studies are comparable to the results of the DWRSIM studies (see Appendix D for a comparison of these model study results).

Although this EIR uses results from the two DWRSIM studies for determining SWP water supplies for both the pre-project 1998 environmental baseline and the project environmental impact analyses, it uses results from the CALSIM II studies from DWR's SWP Delivery Reliability Report (2003b) for determining estimates of SWP water supplies for the current environmental setting.

The estimates of SWP supplies associated with the 41,000 AF of Table A Amount based on DWR's SWP Delivery Reliability Report are slightly lower than the amounts under the DWRSIM studies for the comparable allocation scenario, particularly under "existing" conditions. The difference between SWP supply estimates in this EIR compared to estimates based on DWR's SWP Delivery Reliability Report is due to several reasons, including: (1) the use of two different models (DWRSIM in this EIR and CALSIM II in DWR's report), which show slightly different supply results in some years; (2) the results in this EIR account for the variable demand used by DWR in its model studies (consistent with the way DWR actually allocated water), while the results as presented in DWR's report do not (i.e., in DWR's report deliveries are presented as a percentage of Table A, regardless of the lower demands used in some years of the study); and, (3) the "existing" case in this EIR is based on 1998 SWP demand conditions, while the "existing" case in DWR's report is based on higher 2001 SWP demand conditions. The 2001 total SWP demand is higher than the 1998 demand due to increased M&I Contractor demands. A lower total demand can result in some years in more water being

allocated to the same Table A Amount, so the lower 1998 demand results in a slightly higher quantity of water associated with the 41,000 AF of Table A Amount.

SWP WATER SUPPLY ALLOCATION SCENARIOS

The Project could be authorized under Article 41 of CLWA's original Water Supply Contract with DWR or under terms added to CLWA's contract as part of the Monterey Amendment (Article 53). Both contract terms allow for the transfer of Table A Amount between SWP Contractors. As described in section 1.3.2 under the Monterey Amendment, Agricultural Contractors committed, on a willing buyer-willing seller basis, to make available 130,000 AF of Table A Amount for permanent transfer to M&I Contractors (Article 53). The transfer of Table A Amount that is the subject of this EIR was implemented under this permanent transfer provision of the Monterey Amendment, although the transfer could be implemented under Article 41 of CLWA's original Water Supply Contract.

As was discussed in Chapter 1, DWR is in the process of preparing a new EIR for the Monterey Amendment. Since the Monterey Amendment changes the way SWP supplies are allocated among Contractors, this EIR provides three separate analyses of the Project's impacts to water supply available to WRMWSD and CLWA. The three analyses represent three possible scenarios for allocating available SWP supplies among Contractors, and provide an evaluation of the amount of SWP supply that would be associated with the 41,000 AF of Table A Amount under each of the allocation scenarios. The three analyses are governed by specific terms in the Water Supply Contracts, and are referred to in this EIR as: "SWP Allocation without the Monterey Amendment" (Without Monterey Amendment); "SWP Allocation without the Monterey Amendment and with Implementation of Article 18(b) Permanent Shortage Provision" (With Article 18(b) Implemented); and, "SWP Allocation with the Monterey Amendment" (With Monterey Amendment). The SWP allocation scenarios that form the basis of the three analyses are described below and summarized in Table 3.15-13. DWR is currently allocating SWP supplies in accordance with the Water Supply Contract as amended by the Monterey Amendment ("With Monterey Amendment").

It is important to note that the total amount of SWP supply is independent of the allocation scenario. The total amount of SWP supply available in a given year is a result of that year's hydrology, the amount of storage in SWP reservoirs at the beginning of the year, and the operational constraints that govern operations in the Delta (in 1998, Order WR 95-6 and currently, SWRCB Decision 1641).

***SWP Allocation without the Monterey Amendment (i.e., Initial agricultural reduction in allocations), (Without Monterey Amendment)*** – Under the original terms of the Water Supply Contracts, water supply shortages, as well as any surplus water that might be available, were allocated differently among Contractors depending on whether Contractors' Table A Amounts were classified as agricultural or M&I. Under the original SWP contract terms, in a year with a water supply shortage (i.e., a year when total available SWP supplies were less than Contractor requests), available water supplies were allocated such that Agricultural Contractors received certain initial reductions in deliveries, and any remaining shortages were then allocated proportionately among all Contractors.

Conversely, when surplus water was available, Agricultural Contractors were given priority to this water. This priority to surplus water was given to both scheduled surplus water and unscheduled surplus water (refer to Table 3.15-3 for a definition of scheduled surplus water and unscheduled surplus water). Scheduled surplus water was generally available only during the early years of the SWP, when total Contractor demands were low. Due primarily to increasing Contractor demands for Table A supplies, scheduled surplus water has not been available since the mid-1980s.

Since WRMWSD's Table A Amount is classified as agricultural, the Table A Amount transferred to CLWA would be considered agricultural. Therefore, in this allocation scenario, under shortage conditions the 41,000 AF of Table A Amount would be subject to the initial agricultural reductions. Similarly, under surplus water conditions the 41,000 AF of Table A Amount would have the agricultural priority to surplus water.

***SWP Allocation without the Monterey Amendment and with Implementation of Article 18(b) Permanent Shortage Provision (i.e., Proportionate Reduction in Table A Amounts), (With Article 18(b) Implemented)*** – Under the original terms of the Water Supply Contracts, DWR could invoke Article 18(b) of the Water Supply Contracts if DWR determined that the SWP was in a "permanent shortage" situation. With implementation of Article 18(b), DWR would determine a new "minimum project yield" for the SWP, and reduce Contractors' Table A Amounts proportionately[13] until they equaled the reduced minimum project yield.

There is a great deal of controversy and uncertainty regarding this allocation scenario and how it might have been implemented by DWR. More specifically, there are several different legal and contractual interpretations, particularly between Agricultural and M&I Contractors, primarily regarding whether DWR could have validly invoked Article 18(b), and assuming that it could have done so, how it could have allocated water under Article 18(b). In general, the water allocation rules that would apply under this allocation scenario are similar to the allocation rules described for the Without Monterey Amendment scenario described above, with Agricultural Contractors receiving initial reductions in shortage years and priority to surplus water when it was available. However, with all Contractor Table A Amounts reduced, shortages (i.e., supplies insufficient to meet Contractor requests for Table A water) would occur much less frequently (because the SWP could deliver the smaller Table A Amounts more regularly), and the initial agricultural reduction would be applied to a smaller Table A Amount (i.e., the reductions would be smaller). And with Table A Amounts reduced, SWP supplies in excess of the reduced minimum project yield would be available for scheduled delivery in most years. Unscheduled surplus water would be available under the same conditions, in the same amounts, and allocated in the same way as in the Without Monterey Amendment scenario.

13 Without the Monterey Amendment, Article 18(b) of the Water Supply Contracts stated "In the event that the State is unable to construct sufficient additional conservation facilities to prevent a reduction in the minimum project yield, or if for any other reason there is a reduction in the minimum project yield, which, notwithstanding preventive or remedial measures taken or to be taken by the State, threatens a permanent shortage in the supply of project water to be made available to the contactors: (1) The annual entitlements and the maximum annual entitlements of all Contractors, except to the extent such entitlements may reflect established rights under the area of origin statutes, shall, by amendment of Table A of this contract, be reduced proportionately by the State to the extent necessary so that the sum of the revised maximum annual entitlements of all Contractors will then equal such reduced minimum project yield...."

**Table 3.15-13. Summary of SWP Water Supply Contract Without Monterey Amendment, With Article 18(b) Implemented and With Monterey Amendment Allocation Scenarios**

| | *Without Monterey Amendment* | *With Article 18(b) Implemented* | *With Monterey Amendment* |
|---|---|---|---|
| SWP Supplies Allocated Based on: | Original terms of Water Supply Contracts. | Original terms of Water Supply Contracts, assuming DWR implemented Article 18(b), (i.e., if it determined SWP was in "permanent shortage" situation).<br>All Contractors' Table A Amounts proportionately reduced until they total new "minimum project yield," as determined by DWR. | Terms of Monterey Amendment to Water Supply Contracts. |
| Table A Water Shortage Allocation | Agricultural Contractors receive initial supply reduction (up to 50% of Table A Amount in one year, and up to 100% in any consecutive seven years).<br>Any remaining shortage allocated proportionately among all Contractors. | Same as Without Monterey Amendment[1]. | Shortages allocated in proportion to Contractors' Table A Amounts; no agricultural and M&I allocation differential. |
| Surplus Water Allocation | First priority given to Agricultural Contractors. Two categories of surplus water:<br>• Scheduled surplus.<br>• Unscheduled surplus. | Same as Without Monterey Amendment[2]. | Surplus allocated in proportion to Contractors' Table A Amounts.<br>Scheduled surplus water eliminated.<br>Unscheduled surplus water renamed; referred to as Article 21 water. |
| Results for Contractors | Agricultural Contractors have:<br>• Less reliable Table A supply than M&I Contractors (due to initial agricultural reductions), but,<br>• More access to surplus water. | Supplies shift from M&I Contractors to Agricultural Contractors, due to:<br>• Smaller and less frequent initial agricultural reductions, and,<br>• More of available supply classified as surplus water (with agricultural priority). | Reliability of both Table A supply and surplus supply is same for Agricultural Contractors and M&I Contractors. |

1. Same allocation rules apply, but because Table A Amounts are reduced, initial agricultural reductions are smaller and less frequent.
2. Same allocation rules apply, but because Table A Amounts are reduced, surplus supplies are available more frequently.

There are two primary uncertainties under this allocation scenario. This first unknown is what value of minimum project yield DWR would have used in reducing Table A Amounts. A specific value for minimum project yield had not been calculated in the several years leading up to the Monterey Amendment, but was commonly thought at the time to be in the range of 2.0 to 2.5 million AF (Cal. App. 3d PCL vs. DWR September 15, 2000). The second uncertainty is how any water supply in excess of minimum project yield would have been allocated. This is an area of controversy, with some Contractors contending it should be allocated as surplus water with Agricultural Contractors receiving a priority, and others contending it should be allocated in proportion to Table A Amounts.

Given these uncertainties, two Article 18(b) allocation scenarios that bound the various assumptions and interpretations described above were analyzed for this EIR. The first scenario assumes minimum project yield is reduced to 2.0 million AF, and scheduled surplus water is allocated with priority given to Agricultural Contractors. The second scenario assumes minimum project yield is reduced to 2.5 million AF, and deliveries above this amount are allocated in proportion to Table A Amounts. The first of these scenarios would result in more water being allocated to Agricultural Contractors than the second, and therefore would result in more water being associated with the Project's 41,000 AF of Agricultural Table A Amount. Because this first scenario would result in the worst case for purposes of analysis of potential growth impacts, only the results of the first scenario are presented in this EIR (for the water supply results of both scenarios, refer to Appendix D).

***SWP Allocation with the Monterey Amendment (i.e., Proportionate reduction in allocations), (With Monterey Amendment)*** – Under the terms of the Water Supply Contracts as amended by the Monterey Amendment, all SWP water supplies are shared among all Contractors in proportion to their Table A Amounts. Therefore, the 41,000 AF of Table A Amount transferred to CLWA from WRMWSD would be subject to the same shortages as all other Table A Amounts (i.e., it would not be subject to an initial agricultural reduction and would not have the priority to certain surplus deliveries), and would have access to the same proportionate share of any available surplus water as all other Table A Amounts. As part of the Monterey Amendment, the category of scheduled surplus water was eliminated because it was no longer available, the category of unscheduled surplus water was retained but is now referred to as Article 21 water, and Article 18(b) was deleted.

HYDROLOGIC CONDITIONS

Because SWP water supplies vary from year to year depending on a variety of factors, this EIR presents water supply results for three different hydrologic conditions. A Contractor's "average year" supply is the average quantity of water available to the Contractor, based on the 73 years of DWRSIM model results. A Contractor's "single dry year" supply is the amount of water available to the Contractor in the single year with the lowest total SWP deliveries, based on the DWRSIM model results, which was 1977. The single dry year supply is considered to be a worst-case scenario, with a probability of occurrence of once in 73 years, or about 1.4 percent of the time. A Contractor's "multiple dry year period" supply is the average amount of water available over the four consecutive years drought years of 1988 to 1991, based on the DWRSIM model results.

GENERAL METHODOLOGY

The potential impacts of the Project to WRMWSD and CLWA SWP water supplies and to SWP facilities were evaluated using the general methodology described below. Appendix D provides additional detail on the water supply analysis methodology.

First, the amount of SWP water supply available to WRMWSD and CLWA, including the amount associated with the 41,000 AF of Table A Amount, was analyzed. Data from the DWRSIM model studies discussed above (including the M&I and Agricultural Contractor demands used as input to the studies, and the total annual SWP deliveries to all Contractors from the model study results) were used as a starting point for the analysis. For this analysis, these total annual deliveries were allocated among Contractors in accordance with the three SWP water allocation scenarios described above (Without Monterey Amendment, With Article 18(b) Implemented, and With Monterey Amendment), for each year over the model's period of record. The results of these analyses were used to determine the SWP deliveries that could be expected by WRMWSD and CLWA under each water allocation scenario, for each hydrologic condition considered.

Next, impacts to SWP facilities were analyzed. This analysis also used data from these same DWRSIM model studies as a starting point for the analysis, using model study results related to San Luis Reservoir operations (i.e., reservoir storage, diversions to and releases from storage, and Aqueduct flows upstream and downstream of the reservoir). The change in reservoir storage and Aqueduct flow due to the Project was then estimated based on the difference between WRMWSD and CLWA in the timing of monthly deliveries (i.e., the difference in timing between agricultural use and M&I use), given the allocated supplies determined in the supply analysis.

In the supply analyses conducted for this EIR, the classifications of Table A Amounts as agricultural or as M&I were maintained. The 41,000 AF of Table A Amount transferred from WRMWSD (through KCWA) is agricultural. Although CLWA serves M&I users, the agricultural classification of the 41,000 AF Table A Amount would remain because the classification is determined by the original Water Supply Contract terms according to anticipated use (i.e., KCWA's original Water Supply Contract) and has not changed. Agricultural Table A Amount can be used for M&I uses and, conversely, M&I Table A Amount can be used for agricultural uses. Of CLWA's 54,200 AF of SWP Table A Amount without the Project, 41,500 AF is classified as M&I, and 12,700 AF as agricultural.

In addition to Table A supplies, CLWA and WRMWSD can also receive deliveries of surplus water (see Table 3.15-3 for descriptions of types of surplus water). Unscheduled surplus water/Article 21 water is not included in the water supply analysis for any of the three water allocation scenarios. This is because it is not available on a routine or predictable basis, and is generally only available for short periods of time during low demand months when most Contractors have a limited ability to use it. It is noted, however, that unscheduled surplus water/Article 21 water could provide additional water supplies that could be used by WRMWSD and CLWA. Scheduled surplus water is only included in the With Article 18(b) Implemented allocation scenario, because with the reduced Table A Amounts under that scenario scheduled surplus water would have been available on a scheduled or more

dependable basis similar to Table A supplies (i.e., Contractors could schedule in advance, in a manner similar to their annual Table A requests, deliveries of scheduled surplus water). Scheduled surplus water is assumed to not be available under the Without Monterey Amendment and With Monterey Amendment allocation scenarios because (1) for the Without Monterey Amendment allocation scenario, scheduled surplus water was generally available only during the early years of the SWP, when total Contractor demands were low, and has not been available since the mid-1980s due primarily to increasing Contractor demands for Table A supplies, and (2) for the With Monterey Amendment allocation scenario, the category of scheduled surplus water was eliminated as part of the Monterey Amendment because it was no longer available (refer to Table 3.15-3).

For the purposes of estimating the impacts of the Project, the impact analyses assume that CLWA will take delivery of the entire amount of water made available from the 41,000 AF Table A Amount transferred. This assumption conservatively provides the largest effect on SWP operations, even though CLWA may not currently have the local demand for this entire amount of water in average and wetter hydrologic years.

*State Water Project and Associated Facilities*

DIRECT IMPACTS

The Project would not result in a change in the total amount of SWP supply available for delivery to SWP Contractors. The total amount of SWP supply available in a given year is a result of that year's hydrology, the amount of storage in SWP reservoirs at the beginning of the year, and the operational constraints that govern operations in the Delta (in 1998, SWRCB Order WR 95-6 and currently, SWRCB Decision 1641). The total available SWP supply is then allocated among the SWP Contractors and is independent of the location of use south of the Delta. Impacts described below and summarized in Table 3.15-14 for the SWP and associated facilities are primarily due to two changes as a result of the Project, which are:

- *Change in end use of water associated with the 41,000 AF Table A Amount* – The project would result in a change from agricultural end use to M&I end use of water associated with the 41,000 AF Table A Amount. Typically, agricultural water users use proportionately more of their annual water supply during the heavy irrigation months of the late spring and summer than do urban water users, and proportionately less of their supply than urban users during the remainder of the year. In the case of WRMWSD and CLWA, this difference in delivery during the year would result in a net reduction in deliveries of water associated with the 41,000 AF Table A Amount in May through September, and a net increase in deliveries during the remaining months of the year (October through April). In addition, deliveries to WRMWSD historically have peaked in July, while CLWA's deliveries historically have peaked in August.

- *Changes in the amount of water transported to the CLWA turnouts* – The Project would result in the delivery of water to the CLWA turnout that could have otherwise been delivered to the WRMWSD turnouts. Because the CLWA turnout is located further

down the Aqueduct than the WRMWSD turnout (see Figure 1.3-1), water associated with the Table A transfer would need to be transported this additional distance.

**Table 3.15-14. Summary of Impacts to the SWP and Associated Facilities**

| | |
|---|---|
| The Delta | The Project would not change the total amount of SWP supply available for delivery to Contractors, so there would be no change in the total amount of water diverted from the Delta.<br><br>The difference in timing of water used for urban purposes rather than agricultural purposes would result in a slight change in timing of deliveries of the 41,000 AF of Table A Amount. This change in timing could also result in a slight change in the timing of the filling of San Luis Reservoir, which could result in minor changes in the timing of Delta diversions. However, these changes would fall well within the range of historical and future anticipated SWP diversions from the Delta. Any change in Delta diversions that did occur would result in an imperceptible or minor change in Delta water quality (slight salinity decreases withy lower diversions, and slight salinity increase with higher diversions). All changes would be within applicable water quality standards and agreements. Impacts would be less than significant. |
| California Aqueduct from the Delta to San Luis Reservoir | If the changes in Delta diversions described above occurred, there would be a corresponding change in the timing of water transported in the California Aqueduct from the Delta facilities to San Luis Reservoir. This would not result in an environmental impact to water resources. |
| San Luis Reservoir | The difference in timing of water used for urban purposes rather than agricultural purposes would result in a slight increase in storage at San Luis Reservoir from July through November, and a slight decrease in storage during the remainder of the year. The change in storage at San Luis Reservoir resulting from the Project would represent a small portion of the total average storage in the SWP share of San Luis Reservoir, reflecting storage changes of less than 0.5 percent of average monthly storage in most months and not more than two percent in any month. This would not result in an environmental impact to water resources. |
| California Aqueduct downstream of San Luis Reservoir | The Project would result in a minor change in the timing of water transported in the Aqueduct between San Luis Reservoir and the WRMWSD turnouts, with a slight increase in the amount of water transported from October to April, and a slight decrease during the remainder of the year (May to September). This would not result in an environmental impact to water resources.<br>The Project would result an annual increase of up to 41,000 AF transported in the California Aqueduct from the WRMWSD turnouts to the CLWA turnout. This increase would slightly increase the flow (velocity) in the California Aqueduct and may result in a minor change in the water level within the non-pipeline portions of the Aqueduct. This would not result in an environmental impact to water resources. |
| Castaic Lake | The Project would increase SWP water delivered to CLWA resulting in additional water being conveyed to, and delivered from, Castaic Lake, but would have little effect on the overall storage volume in the lake at any given time. This would not result in an environmental impact to water resources. |
| Other SWP Reservoirs (Quail and Pyramid lakes) | The Project would not result in changes to the overall volume of water stored in either Quail or Pyramid lakes, but would increase the amount of water that is conveyed to and released from the lakes. This would not result in an environmental impact to water resources. |

Unless otherwise noted, the impacts of the Project to the SWP and associated facilities would be similar regardless of the SWP water allocation scenario (Without Monterey Amendment, With Article 18(b) Implemented, and With Monterey Amendment), and under both SWP demand conditions (existing and 2020).

**The Delta** – As discussed above, the Project would not change the total amount of SWP supply available for delivery to the Contractors. Therefore, there would be no change in the total amount of water diverted from the Delta. The difference in the timing of water used for urban purposes by CLWA rather than for agricultural purposes by WRMWSD would result in a slight change in the timing of deliveries of the 41,000 Table A Amount south of the Delta. This slight change in the timing of deliveries would require a slight change in operations (i.e., either in diversions from the Delta or in San Luis Reservoir operations). Generally, the SWP operates to divert as much water from the Delta as is available under prevailing hydrologic conditions, within the water quality standards and operational constraints that govern Delta operations (i.e., currently, SWRCB Decision 1641 and in 1998, Order WR 95-6). This is true regardless of the timing of deliveries south of the Delta because when Delta diversions exceed downstream deliveries, that excess is stored in San Luis Reservoir for delivery later in the year.

Because Delta diversions are limited by either water availability or operational/regulatory constraints, the change in the timing of deliveries of the 41,000 AF of Table A due to the Project would primarily result in changes in San Luis Reservoir storage (as is discussed in more detail below). These changes in storage could in some years result in the reservoir reaching full capacity at a slightly different time than if the Project were not implemented, which in turn could result in a slight change in Delta diversions (because diversions would generally be reduced when storage becomes full). Given the small magnitude of the change in the timing of deliveries, any change in the timing of Delta diversions that did occur would be minor, and would likely be on the order of hours or days (i.e., with the Project, certain changes in Delta diversions that would have occurred without the Project would still occur, but might shift by a few hours or days).

Delta diversions and their effect on Delta water quality vary from year to year. Any minor change in Delta diversions that did occur as a result of the Project would be small relative to total SWP diversions and would fall well within the range of historical and future anticipated SWP diversions from the Delta. Any minor change in the timing of Delta diversions due to the Project would result in an imperceptible or minor change in Delta water quality (slight salinity decrease with lower diversions, and slight salinity increase with higher diversions). Because (1) the Project would not change the operating criteria for diversions from the Delta, (2) the Project would very infrequently result in minor changes to Delta diversions within the applicable environmental and regulatory constraints, and (3) under those conditions that diversions could change, the changes would be minor, the Project would result in less than significant impacts to water resources, including water quality, within the Delta.

**California Aqueduct from the Delta to San Luis Reservoir** – As described above, the change in the timing of deliveries for WRMWSD and CLWA could result in some years in minor changes to Delta diversions. However, these changes would fall well within the range of historical and future anticipated SWP diversions from the Delta. If these timing changes in Delta diversions occurred, there would be a corresponding change in the timing of water transported in the

California Aqueduct from the Delta facilities to San Luis Reservoir. These changes in water transported in the Aqueduct would be minor. Water associated with the 41,000 AF of Table A Amount has historically been transported through this reach, and the amount of water transported would not exceed the capacity of the Aqueduct. Changing the timing of water transported in the Aqueduct would not result in an environmental impact to water resources.

**San Luis Reservoir** – As discussed in section 3.15.1.1, the general operation at San Luis Reservoir is to try to fill the reservoir during the high runoff months of the winter and early spring, and then release the stored water to supplement the more limited diversions from the Delta during the higher-demand summer and fall months to meet Contractor demands. The Project, in combination with the net change in the timing of deliveries during the year between WRMWSD and CLWA, would result in a slight increase in storage at San Luis Reservoir from July through November, and a slight decrease in storage during the remainder of the year. The magnitude of the storage increase would be greatest in August and September, averaging approximately 4,500 AF at existing SWP demand conditions and approximately 4,200 AF at 2020 SWP demand conditions. The magnitude of the reduction in storage would be greatest in March and April, averaging approximately 3,000 AF at existing SWP demand conditions and approximately 2,700 AF at 2020 SWP demand conditions. As shown on Figure 3.15-6, the change in storage at San Luis Reservoir resulting from the Project would represent a small portion of the total average storage in the SWP share of San Luis Reservoir (SWP capacity is over 1 million AF), reflecting storage changes of less than 0.5 percent of average storage in most months and not more than 2 percent in any month. The information provided above and in Figure 3.15-6 is based on implementation of the Project under the terms of the With Monterey Amendment scenario. These storage changes would be similar under the Without Monterey Amendment and With Article 18(b) Implemented scenarios because the amount and timing of deliveries under each of the allocation scenarios is quite similar.

These changes in storage are well within the substantial differences in San Luis Reservoir storage that occur in normal SWP operations over the course of the year and from year to year, and would not result in an environmental impact to water resources at San Luis Reservoir.

**California Aqueduct downstream of San Luis Reservoir** – The Project would result in a minor change in the timing of water transported in the Aqueduct between San Luis Reservoir and the WRMWSD turnouts. Within this reach of the Aqueduct, a slight increase in the amount of water transported would occur from October to April, and a slight decrease would occur during the remainder of the year (May to September). These changes in the amount of water transported from the Delta to the WRMWSD turnouts would result from the change in end use of the water (urban rather than agricultural use) and the associated shift in the timing of delivery. These changes in water transported in the Aqueduct would be minor. Water associated with the 41,000 AF of Table A Amount has historically been transported through this reach, and the amount of water transported would not exceed the capacity of the Aqueduct. Changing the timing of water transported in the Aqueduct would not result in an environmental impact to water resources.

The Project would result in an annual increase of up to 41,000 AF transported in the California Aqueduct from the WRMWSD turnouts to the CLWA turnout. This increase would slightly increase the flow (velocity) in the California Aqueduct and may result in a minor change in the water level within the non-pipeline portions of the Aqueduct. Because these changes in the

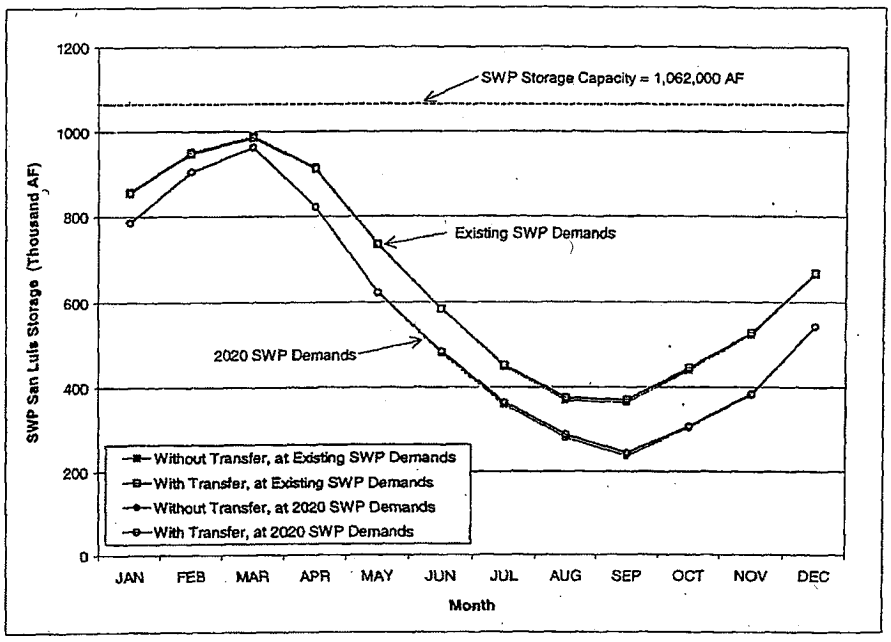



**Figure 3.15-6. Average Monthly SWP San Luis Reservoir Storage With and Without the Project, under With Monterey Amendment SWP Allocations**

amount of water transported in the Aqueduct would be minor, and because the Project would not result in changes to the operating criteria of the Aqueduct (i.e. the additional amount of water would not be allowed to exceed the capacity of the Aqueduct), these changes in timing of flows in the Aqueduct would not result in an environmental impact to water resources.

The Project would require the transport of water associated with the 41,000 AF Table A Amount through the Teerink, Chrisman, Edmonston, and Oso pumping plants (transport to WRMWSD also requires pumping a portion of the water through the Teerink and Chrisman pumping plants) and the Warne and Castaic power plants located within and between WRMWSD and Castaic Lake (refer to Figure 1.1-1). This would not result in an environmental impact to water resources.

The Project would not change the source of water in the California Aqueduct or otherwise affect water quality in the Aqueduct.

**Castaic Lake** – The amount of water stored at Castaic Lake would not be expected to change as a result of the Project. As discussed in section 3.15.1.2, Castaic Lake is the terminal reservoir on the West Branch of the California Aqueduct and is operated to help meet peak deliveries during the summer months for those SWP Contractors that receive deliveries from Castaic Lake and to provide an emergency water supply in case of a major supply system outage. Castaic Lake is also used for year-round recreational purposes. Under normal operations, the amount of storage that is withdrawn from Castaic Lake to make deliveries to Contractors over the summer (the amount withdrawn that exceeds the amount delivered to the lake) is typically about 30,000 AF (or about 10 percent of the lake's volume). The amount of this storage withdrawal is small

relative to total deliveries from the West Branch, which averaged about 403,000 AF from 1990 through 2000. In other words, most deliveries from the West Branch are conveyed through the California Aqueduct and Castaic Lake in about the same month the water is delivered to Contractors from the lake. In the future, DWR is expected to maintain this same general operation at Castaic Lake regardless of whether deliveries from the West Branch increase, and regardless of whether increased deliveries are due to increasing Contractor demands or due to Table A Amount transfers such as the Project.

Over the past decade, CLWA's Table A water deliveries from Castaic Lake have averaged only about 6 percent of the total SWP water delivered from the lake. Over this same period, the majority of the SWP water delivered from the lake (approximately 93 percent) was delivered to MWD due to its relatively larger Table A Amount and storage rights in Castaic Lake. The increase in water delivery to CLWA from the Project would result in additional water being conveyed to, and delivered from, Castaic Lake, but would have little effect on the overall storage volume in the lake at any given time. Because CLWA's deliveries from Castaic Lake with the Project would be minor compared to the total amount of water delivered from the lake, most of the SWP water is conveyed to the lake in the same month it is delivered to CLWA, and the Project would not change DWR's operating criteria for the lake, the Project would not result in an environmental impact to water resources at Castaic Lake. Because the Project would not change the source of water delivered to Castaic Lake and would result in minor, if any changes in the lake's volume, water quality would not be affected.

Although not an impact of the Project, it is noted that flexible storage is a component of the Monterey Amendment. CLWA would only have the ability to access water stored in Castaic Lake under the "flexible storage" provision of the Monterey Amendment in the With Monterey Amendment scenario. The amount of flexible storage available to CLWA would not change as a result of the Project.

**Other SWP Reservoirs** – Quail Lake and Pyramid Lake are located between the WRMWSD turnouts and the CLWA turnout on the West Branch of the California Aqueduct. DWR operates Quail Lake to re-regulate Aqueduct flows. Pyramid Lake is used in the operation of the Castaic Power Plant located between Pyramid and Castaic lakes, as well as to provide an emergency water supply for the West Branch Contractors. The Project would be implemented in accordance with DWR's existing operation of these lakes. As with Castaic Lake, most of the SWP water delivered to both Quail and Pyramid lakes is conveyed to, and released from, the lakes within the same month. Therefore, the Project would not result in changes to the overall volume of water stored in either Quail or Pyramid lakes, but would increase the amount of water that is conveyed to and released from the lakes. Because water is conveyed to and released from these lakes in approximately the same month, and because the project would not result in changes to DWR's operations of these facilities, the Project would not result in an environmental impact to water resources.

INDIRECT IMPACTS

Because the Project would be implemented in accordance with DWR's operation of the SWP and associated facilities, no indirect impacts to water resources would occur.

*Wheeler Ridge-Maricopa Water Storage District*

DIRECT IMPACTS

The Project reduces WRMWSD's Water Supply Contract Table A Amount by 41,000 AF (from 238,088 AF to 197,088 AF, a reduction of 17.2 percent). Because SWP water supplies are allocated among Contractors on the basis of Table A Amounts, this reduction in WRMWSD's Table A Amount would result in a reduction in the total amount of SWP water that WRMWSD could obtain (including both Table A and any available surplus supplies) from the SWP. Under all SWP allocation scenarios and hydrologic conditions, the Project would result in a maximum reduction in the SWP Table A water available to WRMWSD of approximately 17.2 percent.

As discussed in section 3.15.2.2, the supplies presented below are Table A supplies only (or in the case of the allocation scenario With Article 18(b) Implemented, Table A supplies and scheduled surplus water), and do not include unscheduled surplus water/Article 21 water.

Water Supply

***All SWP Allocation Scenarios under Existing SWP Demand Conditions*** – Table 3.15-15 presents the results of the analysis of WRMWSD's SWP Table A supply under the existing (1998) SWP demand conditions used in the DWRSIM study, and under the various hydrologic conditions (average year, single dry year, and multiple dry year period) and water allocation scenarios considered (With Monterey Amendment, Without Monterey Amendment, and With Article 18(b) Implemented). Under current SWP allocation rules (With Monterey Amendment), implementation of the Project would result in a reduction in the Table A supply available to WRMWSD of 34,400 AF, 9,200 AF, and 18,100 AF under the average year, single dry year, and multiple dry year period conditions, respectively. Considering all allocation scenarios, the largest reduction in supplies available to WRMWSD with implementation of the Project would be 35,300 AF under average year conditions With Article 18(b) Implemented; 9,200 AF under a single dry year With Monterey Amendment; and 18,100 AF under a multiple dry year period With Monterey Amendment.

With the Project, WRMWSD would have sufficient SWP supplies at least 57 percent of the time to deliver Table A water in an amount that would independently meet its minimum demands under favorable economic conditions (180,000 AF). In addition, the average amount of Table A water WRMWSD could expect to receive with the Project under all allocation scenarios (157,000 to 169,500 AF) is greater than the average amount of historic SWP water deliveries to WRMWSD from 1990 to 1999 (137,360 AF) by approximately 14 and 23 percent, respectively. With the Project, sufficient SWP Table A water would be available within the district in years of average or greater than average SWP supplies. In years of less than average SWP supplies, and depending on that year's specific demand, WRMWSD may not have sufficient SWP Table A water to meet demands. In these years, WRMWSD would need to rely on other water management actions, such as previously banked water, and/or individual farmers within the district would use additional local groundwater.

As previously discussed, the decision to use local groundwater (i.e., groundwater pumped from wells owned and operated by farmers) or previously banked water supplies on lands within the district is predominately an economic decision made by farmers. In years when SWP deliveries

**Table 3.15-15. WRMWSD's SWP Table A Supply at Existing SWP Demand Conditions, under all SWP Allocation Scenarios[1]**

(all values in AF, rounded to the nearest 100 AF)

| | | *Table A Amount* | *Average Year* | *Single Dry Year* | *Multiple Dry Year Period[2]* |
|---|---|---|---|---|---|
| **With Monterey Amendment** | Without the Project | 238,100 | 199,900 | 53,300 | 105,300 |
| | With the Project | 197,100 | 165,500 | 44,100 | 87,100 |
| | ***Difference[3]*** | ***41,000*** | ***34,400*** | ***9,200*** | ***18,100*** |
| **Without Monterey Amendment** | Without the Project | 238,100 | 189,700 | 0 | 79,700 |
| | With the Project | 197,100 | 157,000 | 0 | 65,900 |
| | ***Difference[3]*** | ***41,000*** | ***32,700*** | ***0*** | ***13,700*** |
| **With Article 18(b) Implemented[4]** | Without the Project | 113,800 | 204,800 | 11,500 | 100,600 |
| | With the Project | 94,200 | 169,500 | 9,500 | 83,200 |
| | ***Difference[3]*** | ***19,600*** | ***35,300*** | ***2,000*** | ***17,300*** |

*Note:* Numbers may not add due to rounding.
1. Based on water deliveries from DWRSIM study 1995D06E-CALFED-771. This study used 1998 DWR estimates of then-existing SWP Contractor demands.
2. Multiple dry year period supplies shown are average annual supplies over a four-year period.
3. Supplies shown are the amount of water attributable to the 41,000 AF of Table A Amount.
4. Under the SWP allocation scenario With Article 18(b) Implemented, the Table A Amounts shown are estimates of WRMWSD's reduced Table A Amount, based on its proportionate share of a reduced SWP minimum project yield of 2.0 million AF. The supplies shown include both Table A supplies and scheduled surplus supplies estimated to be available, with surplus supplies allocated based on priority for agricultural use.

are less than crop demands, individual farmers may choose to use local groundwater to meet demands. Because WRMWSD has substantially diversified its water sources through other water management actions, resulting in sufficient water available to the district to meet demands in most years at a lower fixed cost (when total costs are considered) than SWP water, increased reliance on groundwater would likely be a result of independent actions by the individual farmers (refer to Appendix C). However, it is reasonable to assume that some farmers may use local groundwater when SWP deliveries are not sufficient to meet demands, and, therefore, the Project may result in additional groundwater pumping in these years. Due to the complexity of factors that may be considered by individual farmers when deciding to use local groundwater in lieu of using imported water, the exact amount of additional reliance on groundwater that may occur in dry years cannot be determined. Because the Project could result in a reduction of up to 9,200 AF of Table A water in a single dry year and up to 18,100 AF of Table A water in a multiple dry year period, this is assumed to be the amount of additional groundwater use that could result from implementation of the Project in these year types. These amounts are small relative to the total amount of water in storage in the Kern County Groundwater Basin (total storage is 40 million AF; DWR 2003a) and the White Wolf sub-basin (total storage is about 2.5 million AF; BE 1975). Because groundwater levels in the portions of these basins underlying WRMWSD generally have been increasing over time (BE 1995), indicating that the basins could sustain an increase in use under these limited conditions

without resulting in a net deficit in aquifer volume or a lowering of the local groundwater table, impacts to groundwater would be less than significant.

As was discussed previously, the supplies presented above do not include unscheduled surplus water/Article 21 water. Generally, when this type of water is available, there is enough to meet all Contractor requests for it. It is only when total Contractor requests for this water exceed the amount available that DWR would need to allocate that limited supply among Contractors. If this situation occurred, the Project could result in a reduction in the amount of unscheduled surplus water/Article 21 water that WRMWSD could obtain (because it is allocated based on Contractor Table A Amounts). Because this reduction is minor, and would only occur infrequently, the reduction in the amount of unscheduled surplus water/Article 21 water that WRMWSD could obtain would not materially affect WRMWSD's surplus water supply and the impact would be less than significant.

***All SWP Allocation Scenarios under 2020 SWP Demand Conditions*** – Table 3.15-16 presents the results of the analysis of WRMWSD's SWP Table A supply under the 2020 SWP demand conditions used in the DWRSIM study, and under the various hydrologic conditions considered (average year, single dry year, and multiple dry year period) and water allocation scenarios (With Monterey Amendment, Without Monterey Amendment, and With Article 18(b) Implemented). Under current SWP allocation rules (With Monterey Amendment), implementation of the Project would result in a reduction in the Table A supply available to WRMWSD of 32,000 AF, 9,200 AF, and 17,600 AF under the average year, single dry year, and multiple dry year period conditions, respectively. Considering all allocation scenarios, the largest reduction in supplies available to WRMWSD with implementation of the Project would be: 34,900 AF under average year conditions With Article 18(b) Implemented; 9,200 AF under a single dry year With Monterey Amendment; and 17,600 AF under a multiple dry year period With Monterey Amendment.

The amount of SWP supply available for a given Table A Amount is somewhat less under 2020 SWP demand conditions than under the existing SWP demand conditions discussed previously. This SWP supply reduction is primarily due to two factors: an increase in future water use upstream of the Delta, which reduces the amount of water flowing into the Delta and therefore the amount available for SWP supplies; and, an increase in SWP Contractor demands, which in certain years when supplies are limited, can result in less SWP supply being allocated to a given Table A Amount. This supply reduction is independent of the Project, and can be seen by comparing the supplies between Table 3.15-15 (existing SWP demands) and Table 3.15-16 (2020 SWP demands). Assuming that future WRMWSD water demand remains at current levels, it is likely that WRMWSD would need to rely more on other water management actions and/or individual farmers within the district would use additional local groundwater (i.e., groundwater pumped from wells owned and operated by farmers) to meet demands within the district (refer to Appendix C). This would occur with or without the Project, although the Project would exacerbate this condition.

Under current SWP allocation rules (With Monterey Amendment) and with implementation of the Project, WRMWSD could expect to receive at least 180,000 AF (their minimum demands under favorable economic conditions) approximately 31 percent of the time, and at least 190,000 AF approximately 20 percent of the time. In addition, WRMWSD could expect to receive an

**Table 3.15-16. WRMWSD's SWP Table A Supply at 2020 SWP Demand Conditions, Under all SWP Allocation Scenarios[1]**
(all values in AF, rounded to the nearest 100 AF)

| | | *Table A Amount* | *Average Year* | *Single Dry Year* | *Multiple Dry Year Period[2]* |
|---|---|---|---|---|---|
| **With Monterey Amendment** | Without the Project | 238,100 | 185,700 | 53,500 | 102,200 |
| | With the Project | 197,100 | 153,800 | 44,300 | 84,600 |
| | ***Difference[3]*** | ***41,000*** | ***32,000*** | ***9,200*** | ***17,600*** |
| **Without Monterey Amendment** | Without the Project | 238,100 | 165,300 | 42,200 | 98,100 |
| | With the Project | 197,100 | 136,900 | 35,000 | 81,200 |
| | ***Difference[3]*** | ***41,000*** | ***28,500*** | ***7,300*** | ***16,900*** |
| **With Article 18(b) Implemented[4]** | Without the Project | 113,800 | 202,900 | 12,300 | 99,300 |
| | With the Project | 94,200 | 168,000 | 10,200 | 82,200 |
| | ***Difference[3]*** | ***19,600*** | ***34,900*** | ***2,100*** | ***17,100*** |

*Note:* Numbers may not add due to rounding.
1. Based on water deliveries from DWRSIM study 2020D09C-CALFED-786.
2. Multiple dry year period supplies shown are average annual supplies over the four-year period.
3. Supplies shown are the amount of water attributable to the 41,000 AF of Table A Amount.
4. Under the SWP allocation scenario With Article 18(b) Implemented, the Table A Amounts shown are estimates of WRMWSD's reduced Table A Amount, based on its proportionate share of a reduced SWP minimum project yield of 2.0 million AF. The supplies shown include both Table A supplies and scheduled surplus supplies estimated to be available, with surplus supplies allocated based on priority for agricultural use.

average SWP Table A supply approximately 11 percent greater than historic SWP deliveries to WRMWSD from 1990 to 1999 (137,360 AF). Considering all allocation scenarios, with implementation of the Project WRMWSD could expect to receive average SWP Table A supplies ranging from approximately 136,900 AF to 168,000 AF, which is approximately 0.3 percent less to 22 percent more than the amount of historic SWP deliveries to WRMWSD from 1990 to 1999.

As previously discussed, the decision to use local groundwater (i.e., groundwater pumped from wells owned and operated by farmers) or other previously banked water supplies on lands within WRMWSD is predominately an economic decision made by farmers. Due to the complexity of factors that may be considered by individual farmers when deciding to use local groundwater in-lieu of using imported water, the exact amount of additional reliance on groundwater that may occur in dry years cannot be determined (refer to Appendix C). Because the Project could result in a reduction in average year SWP supplies below historic average deliveries to WRMWSD from 1990 to 1999 (only in the Without Monterey Amendment scenario) of up to 9,200 AF of Table A water in a single dry year, and up to 17,600 AF of Table A water in a multiple dry year period, this is assumed to be the amount of additional use of local groundwater that could be contributed by the Project in these year types. These amounts are small relative to the total amount of water in storage in the Kern County Groundwater Basin (total storage is 40 million AF; DWR 2003a) and the White Wolf sub-basin (total storage is about 2.5 million AF; BE 1975). Because groundwater levels in the portions of these basins underlying

WRMWSD have been generally increasing over time (BE 1995), indicating that the basins could sustain an increase in use under these limited conditions without resulting in a net deficit in aquifer volume or a lowering of the local groundwater table, impacts to groundwater would be less than significant.

For reasons similar to those identified above, the Project would result in a minor reduction in the amount of unscheduled surplus water/Article 21 water that WRMWSD could obtain, although this reduction would not materially affect WRMWSD's surplus water supply.

***Comparison of WRMWSD Supplies Presented to Supplies based on DWR's Recent SWP Delivery Reliability Report*** – As discussed in section 3.15.2.2, DWR recently completed an analysis of the delivery reliability of the SWP in its SWP Delivery Reliability Report. This DWR report presents the results of CALSIM II model studies run using current allocation rules (i.e., With Monterey Amendment). Starting with these same DWR results and applying the same methodology suggested by DWR in its report, the Project would result in a decrease in WRMWSD's SWP supplies: under "existing" (2001 in DWR's SWP Delivery Reliability Report) conditions of 29,400 AF, 8,000 AF, and 14,800 AF under the average year, single dry year, and multiple dry year period conditions, respectively; and under 2020 conditions of 30,600 AF, 8,200 AF, and 15,000 AF under the average year, single dry year, and multiple dry year period conditions, respectively.

Water Quality

***All SWP Allocation Scenarios under Existing SWP Demand Conditions*** – Overall, within the WRMWSD the Project may result in a minor increase in the use of previously banked water and local groundwater in the drier hydrologic years. Water banked outside of the WRMWSD would be delivered to the district as a SWP water exchange, and would be the same quality as SWP supplies. Water banked within the WRMWSD would be the same quality as the groundwater quality, which has slightly higher TDS than SWP water. The Project may result in a minor increase in the use of water banked with the district and groundwater in the drier hydrologic years, and these sources generally have higher TDS concentrations. Because this water is of sufficient quality for agricultural operations, impacts to surface water quality would be less than significant. Because the increased use of water banked within the district and local groundwater would be minor and would occur infrequently (in drier hydrologic years), the minor use of these supplies and the additional increase in TDS from irrigation related uses would result in less than significant impacts to groundwater quality.

***All SWP Allocation Scenarios under 2020 SWP Demand Conditions*** - The decrease in SWP delivery reliability due to an increase in future levels of demand by M&I Contractors would result, with the transfer, in the use of more groundwater and banked water to meet agricultural needs within the WRMWSD. For the reasons noted above, impacts to surface and groundwater quality would be less than significant.

INDIRECT IMPACTS

No indirect impacts to water resources would occur.

*Castaic Lake Water Agency*

DIRECT IMPACTS

Potential direct impacts from implementation of the Project to water supply, including groundwater resources and water quality are addressed below. Because the Project would be implemented using existing CLWA facilities and new facilities would not be required, construction and land disturbance related impacts would not occur.

The Project increases CLWA's Water Supply Contract Table A Amount by 41,000 AF (from 54,200 AF to 95,200 AF, an increase of 75.6 percent). Because SWP water supplies are allocated among Contractors on the basis of Table A Amounts, this increase in Table A would result in an increase in the total amount of SWP water that CLWA could obtain (including both Table A and any available surplus water supplies). Under all SWP allocation and hydrologic scenarios, the Project would result in a maximum increase in the SWP Table A water available to CLWA of approximately 75.6 percent.

As discussed in section 3.15.2.2, the supplies presented below are Table A supplies only (or in the case of the allocation scenario With Article 18(b) Implemented, Table A supplies and scheduled surplus water), and do not include unscheduled surplus water or Article 21 water.

Water Supply

*All SWP Allocation Scenarios under Existing SWP Demand Conditions* – Table 3.15-17 presents the results of the analysis of CLWA's SWP Table A supply under the existing (1998) SWP demand conditions used in the DWRSIM study, and under the various hydrologic conditions (average year, single dry year, and multiple dry year period) and water allocation scenarios (With Monterey Amendment, Without Monterey Amendment, and With Article 18(b) Implemented) considered. Under current SWP allocation rules (With Monterey Amendment), implementation of the Project would result in an increase in the Table A supply available to CLWA of 34,400 AF, 9,200 AF, and 18,100 AF under the average year, single dry year, and multiple dry year period conditions, respectively. Considering all allocation scenarios, the largest increase in supplies available to CLWA with implementation of the Project would be 35,300 AF under average year conditions With Article 18(b) Implemented; 9,200 AF under a single dry year With Monterey Amendment; and 18,100 AF under a multiple dry year period With Monterey Amendment. The Project would increase CLWA's SWP Table A Amount and increase the amount of SWP water that could be delivered to CLWA. This increased water supply would serve the needs of both existing water users and a portion of future water demand from anticipated growth within the CLWA service area.

Because CLWA could obtain up to an additional 41,000 AF of Table A water (depending on hydrologic conditions) to meet water demands of existing users and a portion of future water demand from anticipated growth within the service area, the Project would have a beneficial impact to water supplies in the CLWA service area. Because the Project would increase the amount of SWP water delivered to the CLWA service area, replacing water that could have otherwise been pumped from groundwater, the Project would have a beneficial impact to groundwater resources via indirect recharge (or percolation) through irrigation with SWP water.

**Table 3.15-17. CLWA's Total SWP Table A Supply at Existing SWP Demand Conditions, under all SWP Allocation Scenarios[1]**
(all values in AF, rounded to the nearest 100 AF)

| | | *Table A Amount* | *Average Year* | *Single Dry Year* | *Multiple Dry Year Period* |
|---|---|---|---|---|---|
| **With Monterey Amendment** | Without the Project | 54,200 | 46,500 | 12,100 | 24,000 |
| | With the Project | 95,200 | 80,900 | 21,300 | 42,100 |
| | ***Difference[3]*** | ***41,000*** | ***34,400*** | ***9,200*** | ***18,100*** |
| **Without Monterey Amendment** | Without the Project | 54,200 | 47,400 | 13,100 | 25,200 |
| | With the Project | 95,200 | 80,100 | 13,100 | 38,900 |
| | ***Difference[3]*** | ***41,000*** | ***32,700*** | ***0*** | ***13,700*** |
| **With Article 18(b) Implemented[4]** | Without the Project | 25,900 | 46,400 | 12,900 | 24,400 |
| | With the Project | 45,500 | 81,700 | 14,900 | 41,700 |
| | ***Difference[3]*** | ***19,600*** | ***35,300*** | ***2,000*** | ***17,300*** |

*Note:* Numbers may not add due to rounding.
1. Based on water deliveries from DWRSIM study 1995D06E-CALFED-771. This study used 1998 DWR estimates of then-existing SWP Contractor demands.
2. Multiple dry year period supplies shown are average annual supplies over the four-year period.
3. Supplies shown are the amount of water attributable to the 41,000 AF of Table A Amount.
4. Under the SWP allocation scenario With Article 18(b) Implemented, the Table A Amounts shown are estimates of CLWA's reduced Table A Amount, based on its proportionate share of a reduced SWP minimum project yield of 2.0 million AF. The supplies shown include both Table A supplies and scheduled surplus supplies estimated to be available, with surplus supplies allocated based on priority for agricultural use.

As was discussed previously, the supplies presented above do not include unscheduled surplus water/Article 21 water. Generally, when this type of water is available, there is enough to meet all Contractor requests for it. It is only when total Contractor requests for this water exceed the amount available that DWR would need to allocate that limited supply among Contractors. If this situation occurred, the Project could result in an increase in the amount of unscheduled surplus water/Article 21 water that CLWA could obtain (because it is allocated based on Contractor Table A Amounts). Since this increase would only occur infrequently, the increase in the amount of unscheduled surplus water/Article 21 water that CLWA could obtain would not materially affect CLWA's surplus water supply.

***All SWP Allocation Scenarios under 2020 SWP Demand Conditions*** – Table 3.15-18 presents the results of the analysis of CLWA's SWP Table A supply under the 2020 SWP demand conditions used in the DWRSIM study, and under the various hydrologic conditions (average year, single dry year, and multiple dry year period) and water allocation scenarios (With Monterey Amendment, Without Monterey Amendment, and With Article 18(b) Implemented) considered. Under current SWP allocation rules (With Monterey Amendment), implementation of the Project would result in an increase the Table A supply available to CLWA of 32,000 AF, 9,200 AF, and 17,600 AF under the average year, single dry year, and multiple dry year period conditions, respectively. Considering all allocation scenarios, the largest increase in supplies available to CLWA with implementation of the Project would be: 34,900 AF under the average year With Article 18(b) Implemented; 9,200 AF under a single dry year With Monterey Amendment; and 17,600 AF under a multiple dry year period With Monterey Amendment.

The Project would increase CLWA's SWP Table A Amount and increase the amount of SWP water that could be delivered to CLWA. This increased water supply would serve the needs of both existing water users and a portion of future water demand from anticipated growth within

the CLWA service area. Because CLWA could obtain up to an additional 41,000 AF of Table A water (depending on hydrologic conditions) to meet water demands of existing users and a portion of future water demand from anticipated growth within the service area, the Project would have a beneficial impact to water supplies in the CLWA service area. Because the Project would increase the amount of SWP water delivered to the CLWA service area, replacing water that could have otherwise been pumped from groundwater, the Project would have a beneficial impact to groundwater resources via indirect recharge (or percolation) through irrigation with SWP water.

For reasons similar to those identified above, the Project would result in an increase in the amount of unscheduled surplus water/Article 21 water that CLWA could obtain, although this increase would not materially affect CLWA's surplus water supply.

**Table 3.15-18. CLWA's Total SWP Table A Supply at 2020 SWP Demand Conditions, under all SWP Allocation Scenarios[1]**
(all values in AF, rounded to the nearest 100 AF)

| | | *Table A Amount* | *Average Year* | *Single Dry Year* | *Multiple Dry Year Period[2]* |
|---|---|---|---|---|---|
| **With Monterey Amendment** | Without the Project | 54,200 | 42,900 | 12,200 | 23,300 |
| | With the Project | 95,200 | 74,900 | 21,400 | 40,900 |
| | ***Difference[3]*** | ***41,000*** | ***32,000*** | ***9,200*** | ***17,600*** |
| **Without Monterey Amendment** | Without the Project | 54,200 | 43,500 | 12,400 | 23,300 |
| | With the Project | 95,200 | 72,000 | 19,600 | 40,200 |
| | ***Difference[3]*** | ***41,000*** | ***28,500*** | ***7,300*** | ***16,900*** |
| **With Article 18(b) Implemented[4]** | Without the Project | 25,900 | 43,000 | 12,800 | 23,300 |
| | With the Project | 45,500 | 78,000 | 15,000 | 40,400 |
| | ***Difference[3]*** | ***19,600*** | ***34,900*** | ***2,100*** | ***17,100*** |

*Note:* Numbers may not add due to rounding.
1. Based on water deliveries from DWRSIM study 2020D09C-CALFED-786.
2. Multiple dry year period supplies shown are average annual supplies over the four-year period.
3. Supplies shown are the amount of water attributable to the 41,000 AF of Table A Amount.
4. Under the SWP allocation scenario With Article 18(b) Implemented, the Table A Amounts shown are estimates of CLWA's reduced Table A Amount, based on its proportionate share of a reduced SWP minimum project yield of 2.0 million AF. The supplies shown include both Table A supplies and scheduled surplus supplies estimated to be available, with surplus supplies allocated based on priority for agricultural use.

***Comparison of CLWA Supplies Presented to Supplies based on DWR's Recent SWP Delivery Reliability Report*** – The existing SWP water supplies included in Table 3.15-7 are based on results from DWR's recent SWP Delivery Reliability Report, which presents the results of CALSIM II model studies run using current allocation rules (i.e., With Monterey Amendment). Starting with these same DWR results and applying the same methodology suggested by DWR in its report, the Project would result in an increase in CLWA's SWP supplies: under "existing" (2001 in DWR's SWP Delivery Reliability Report) conditions of 29,400 AF, 8,000 AF, and 14,800 AF under the average year, single dry year, and multiple dry year period conditions,

respectively; and under 2020 conditions of 30,600 AF, 8,200 AF, and 15,000 AF under the average year, single dry year, and multiple dry year period conditions, respectively.

Water Quality

The Project would result in the delivery of additional SWP water to the CLWA service area when demands are sufficient to make such deliveries feasible. Although SWP water quality varies from year to year depending on hydrologic conditions, regardless of the SWP allocation scenario (With Monterey Amendment, Without Monterey Amendment, and With Article 18(b) Implemented) and the SWP demand conditions (existing or 2020), the Project would not result in a direct impact to water quality within the CLWA service area. CLWA and the local purveyors would continue to meet all applicable drinking water standards and water quality criteria.

The Project would not result in direct surface water quality impacts. CLWA has no discharge permits regulating water quality and is only regulated with regard to the drinking water quality of distributed potable water. It is the actual use of the imported water and discharge after use (i.e., as wastewater) that has the potential to affect water quality of surface waters. This potential impact was considered in the Basin Plan and is considered in the discussion of indirect growth-related impacts in Chapter 4. The Project would not affect the frequency and magnitude of flood flow releases or spills from Castaic Lake. These events are related to rights of downstream users and not related to CLWA or the Project.

INDIRECT IMPACTS

Potential impacts from population growth that could occur as an indirect impact of the Project are addressed in Chapter 4, Growth-Inducing Effects and Growth-Related Impacts.

### 3.15.3 Mitigation Measures

#### *3.15.3.1 State Water Project and Associated Facilities*

No significant direct or indirect impacts to water resources were identified; therefore no mitigation measures are required.

#### *3.15.3.2 Wheeler Ridge-Maricopa Water Storage District*

No significant direct or indirect impacts to water resources were identified; therefore no mitigation measures are required.

#### *3.15.3.3 Castaic Lake Water Agency*

No significant direct impacts to water resources were identified; therefore no mitigation measures are required. Mitigation measures for indirect impacts are addressed in Chapter 4, Growth-Inducing Effects and Growth-Related Impacts.

### 3.15.4 Significant Unavoidable Impacts

No direct or indirect significant unavoidable adverse impacts have been identified within the SWP and associated facilities or within WRMWSD. No direct significant unavoidable adverse impacts have been identified within the CLWA service area. Indirect impacts within the CLWA service area, including significant unavoidable adverse impacts are addressed in Chapter 4, Growth-Inducing Effects and Growth-Related Impacts.

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**455 Capitol Mall**
**Suite 703**
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**95814**
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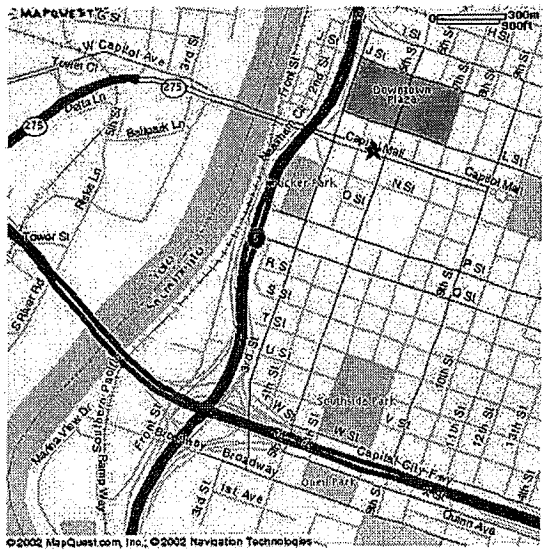


## *Parking Garages*

*are located on **"L" STREET** under Macy's, on **3RD STREET** between **"L"** and **"K"**; off **5TH STREET** behind 455 Capitol Mall, and off **4TH STREET** in the Wells Fargo Bank Building.*

**From the WEST on I-80**, take **CAPITOL CITY FREEWAY**. Take the **JEFFERSON BLVD** exit towards **DOWNTOWN SACRAMENTO**. Merge on **CA-275 NORTH** towards **WEST SAC.** Cross the **TOWER BRIDGE** and you will be on **"CAPITOL MALL."** Turn **LEFT** at **5TH STREET** and the **5TH STREET** parking lot will be on your **LEFT**. Continue on **5TH STREET** and make a **LEFT** on **"L"** for the **"L" STREET** garages and to access the **4TH STREET** parking lot.

**From the SOUTH on I-5**, exit at **"Q" STREET**. Bear **RIGHT** on **"Q" STREET**. Turn **LEFT** on **5TH STREET**. Cross **"CAPITOL MALL"** and the **5TH STREET** parking lot will be on your **LEFT**. Continue on **5TH STREET** and make a **LEFT** on **"L"** for the **"L" STREET** garages and to access the **4TH STREET** parking lot.

**From the EAST**, Take **HWY 50** to **I-5 NORTH**. Exit **"Q" STREET**. Take a **LEFT** at **5TH STREET**. Cross **"CAPITOL MALL"** and the **5TH STREET** parking lot will be on your **LEFT**. Continue on **5TH STREET** and make a **LEFT** on **"L"** for the **"L" STREET** garages and to access the **4TH STREET** parking lot.

**From the NORTHWEST on I-5**. Take the **"J" STREET** exit. Turn **RIGHT** on **5TH STREET** and **RIGHT** again on **"L"** for the **"L" STREET** garages. Continue on **"L" STREET** and take a **LEFT** on **4TH STREET** to access the **4TH STREET** parking lot. Take a **LEFT** on **"CAPITOL MALL"** and another **LEFT** on **5TH STREET** to access the **5TH STREET** parking lot.

**From the NORTHEAST**, Take **I-80** to **I-5 SOUTH** and follow directions above. **OR**, take **CAPITOL CITY FREEWAY** and exit at **"P" STREET**. Go **WEST** until you reach **5TH STREET**. Turn **RIGHT**. Cross **"CAPITOL MALL"** and the **5TH STREET** parking lot will be on your **LEFT**. Continue on **5TH STREET** and make a **LEFT** on **"L"** for the **"L" STREET** garages and to access the **4TH STREET** parking lot.

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Attachment 24

CAPITOL OFFICE
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EAST CHANNEL STREET
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1020 N STREET, ROOM 502
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# California State Senate

MICHAEL J. MACHADO
SENATOR, FIFTH DISTRICT

COMMITTEES
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AGRICULTURE AND WATER RESOURCES
BUSINESS AND PROFESSIONS
GOVERNMENTAL ORGANIZATION
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CAPITOL AREA FLOOD PROTECTION
CENTRAL VALLEY ECONOMIC DEVELOPMENT
DELTA RESOURCES AND DEVELOPMENT
CHAIR
INTERNATIONAL TRADE POLICY AND STATE LEGISLATION

October 30, 2002

Director Tom Hannigan
Department of Water Resources
1416 Ninth Street
Sacramento, CA 95814

Dear Director Hannigan:

I have asked the California Research Bureau to comment on the Draft State Water Project (SWP) Supply Reliability report because questions are being raised by many in the water community regarding the conclusions of the report. With outstanding questions still not addressed, it will be difficult to make progress on many of the critical water issues facing the state.

- Local development could be hampered if, when complying with SB 221 (Kuehl) and SB 610 (Costa) or California's Environmental Quality Act (CEQA), there are significant disputes over current and future water supplies.

- Conclusions of CalFed's Integrated Storage Investigation (ISI) will be suspect given that the same model is used in both the ISI and the SWP Reliability reports.

- Future statewide bonds for increasing water supply will be in jeopardy, if opponents can credibly challenge the underlying analysis.

It is critical that the final SWP Reliability report has widespread support. Until the Department of Water Resources (DWR) resolves concerns raised, the report seems premature and could lead to additional water challenges in the future.

Sincerely,

MICHAEL J. MACHADO
Senator, Fifth District

MJM:bw

Cc: Jonas Minton, Department of Water Resources
Lucinda Chipponeri, Department of Water Resources

**Comments on the Department of Water Resources' Draft State Water Project Supply Reliability Report**

**Dennis O'Connor, Assistant Director**
**California Research Bureau**

**November 1, 2002**

The Department should be commended for attempting to accurately describe the State Water Project's (SWP) supply reliability. If Californians are to plan effectively for their water future, it is important to that we describe our water supply reliability accurately and thereby avoid basing decisions on assumptions about water that exists only on paper. However, as these comments show, the Department's attempt so far falls short of this goal.

Senator Mike Machado asked that the California Research Bureau comment on the Draft State Water Project Supply Reliability Report (Report). He did so because there appears to be a lack of widespread confidence in the conclusions of the report. In particular, many think the modeling behind the report overstates the supply reliability of the SWP. If this is true, then instead of a "paper water" problem, we might have a "cyber water" problem.

## What Does The Report Say?

The purpose of the report is to "assist the contractors of the State Water Project in the assessment of the adequacy of the SWP component of their overall water supplies."* It does so by constructing *delivery probability* charts for the SWP. These charts show the probability of the SWP delivering from the Sacramento-San Joaquin Delta a given quantity of water for a given year under a given set of conditions.

The Department calculated delivery probability charts for two years, 2001 and 2021. For both years, the Department assumed the current water facilities continue to operate as they do now. That is, no new water facilities would be added or removed, there would be no changes in operating rules or regulatory restrictions, etc. The only thing that would change between the two years is the "level of development"; that is, the amount of water used upstream of the Delta. That amount changes between 2001 and 2021 based on assumptions about future population growth and development. For both years, the Department assumes "variable demand"; that is, contractors will change the amount of water they request based on how wet or dry the year is. In addition, the Department created a delivery probability chart for 2021 that assumed all contractors requested their full "Table A" or contractual amount. (Table A amounts were formerly known as entitlements.)

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* California Department of Water Resources. *The State Water Project Delivery Reliability Report,* Draft. (Sacramento: The Department), August 2002. p. iii

In addition to Table A amounts, the Department also calculated delivery probabilities for Article 21 water. Article 21 water, also known as surplus water, refers to water that is available once all SWP demands are met. This means the reservoirs are full, all Table A requests are met, and there is still water legally available to export from the Delta.

The result of all this analysis was a series of delivery probability charts. The figure below shows the delivery probability chart for the 2001 level of development. The chart shows Table A delivery on the left axis, and the corresponding percent of full Table A contractual amounts on the right. The bottom axis shows the percent of time one would expect to receive a given quantity of water. The chart shows that for the 2001 level of development, the SWP would be able to deliver at least 804 thousand acre-feet (taf) of water 100 percent of the time – 804 taf is the minimum the SWP would ever deliver. The most the SWP would be able to deliver would be 3,845 taf. The median delivery is 3,297 taf. As the chart shows, the median delivery is the amount of water that corresponds to the 50 percent probability level. This means that for the 2001 level of development, half the time the SWP would deliver more than 3,297 taf, and half the time the SWP would deliver less.

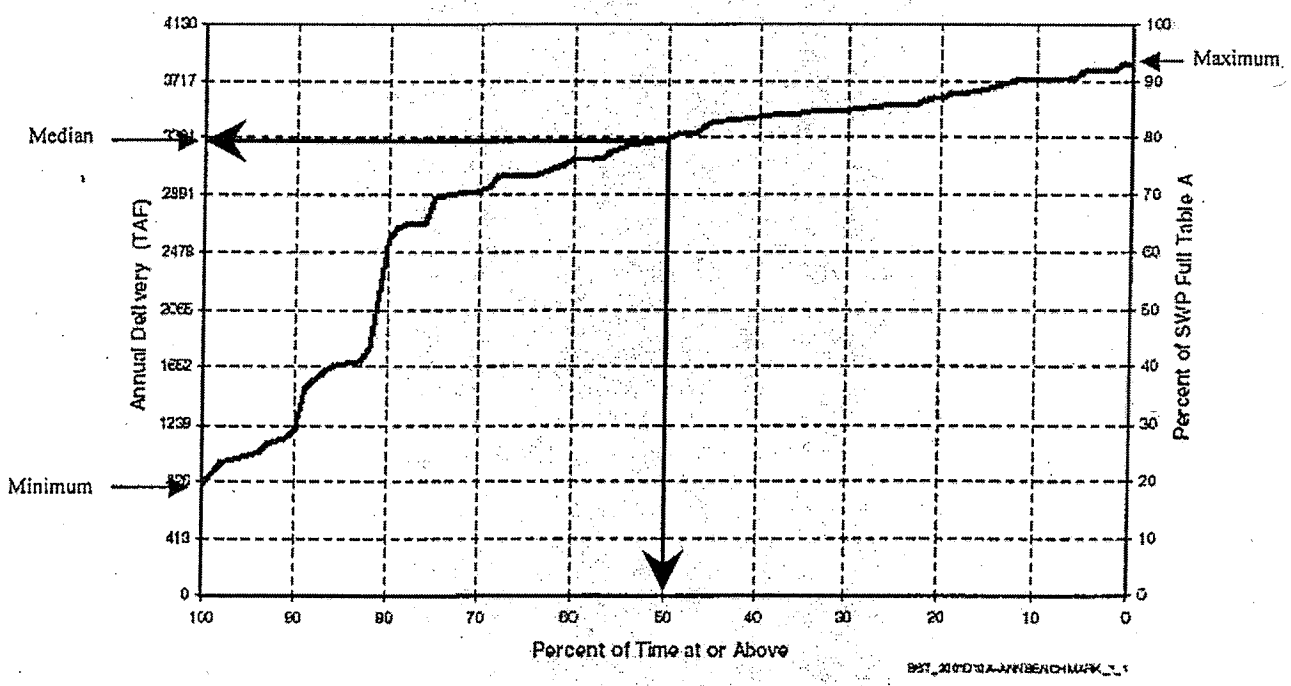



**Figure B-1 Study 2001 SWP Delta delivery reliability**

Similar charts were created for 2021 level of demand with contractor demands that vary with the weather and for 2021 with full Table A demand.

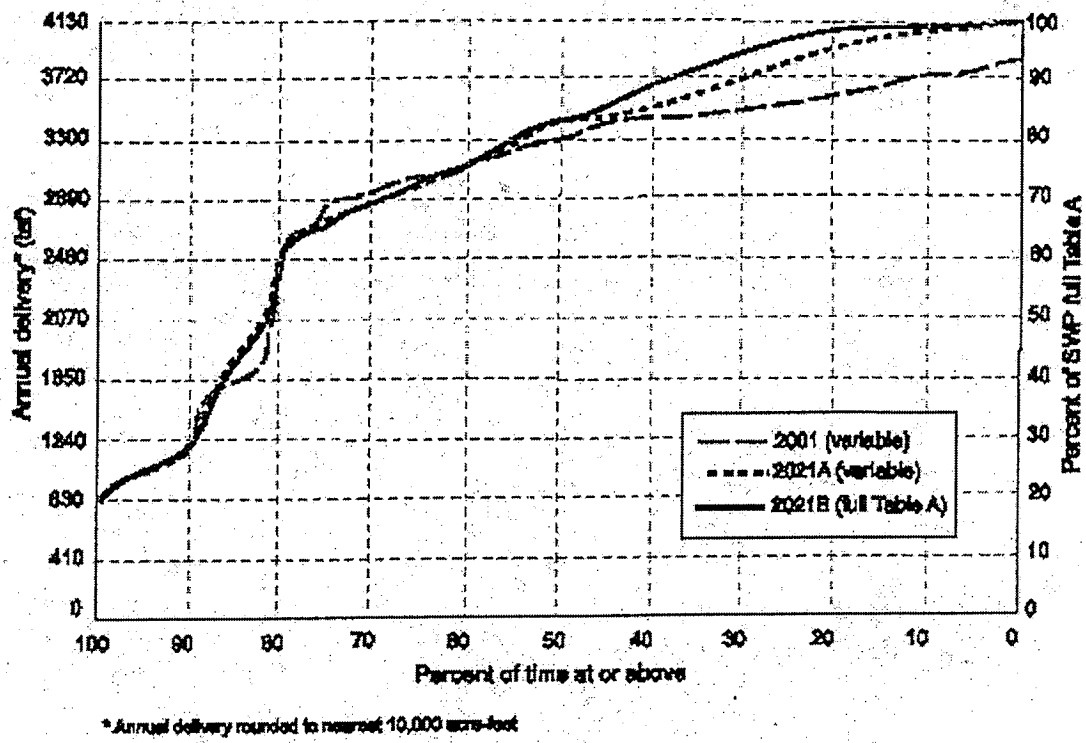
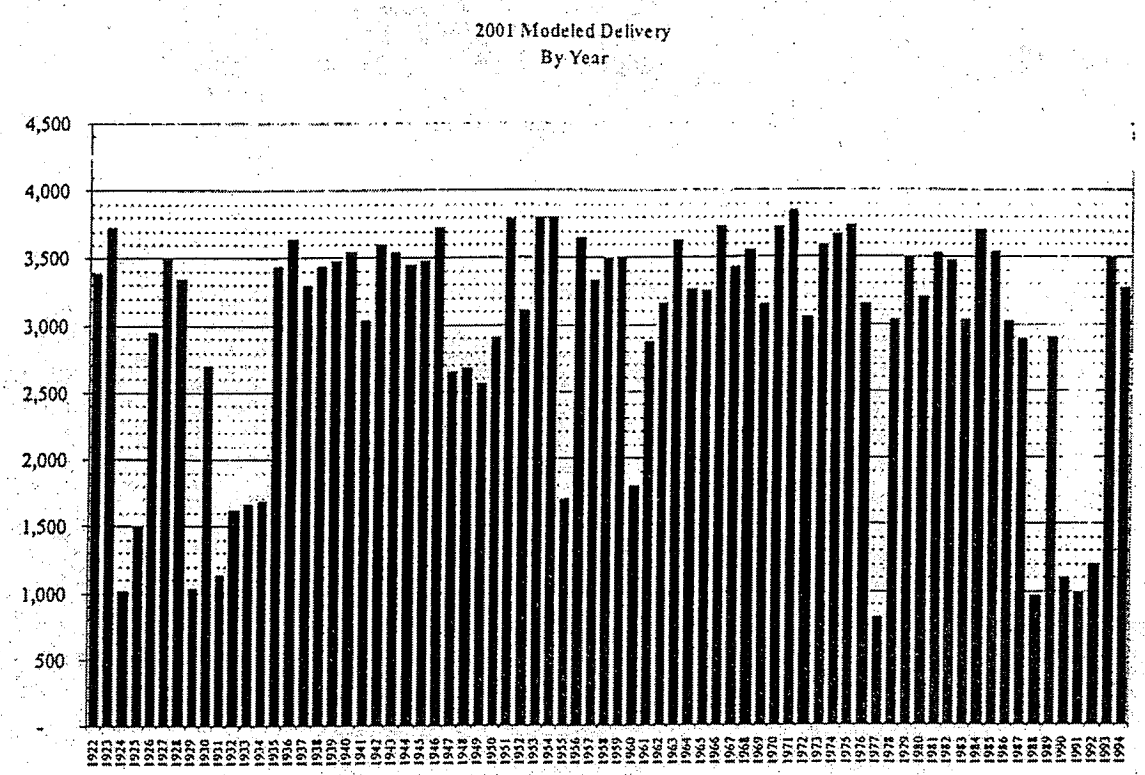



**Figure 1 SWP Delta delivery probability (Table A)**

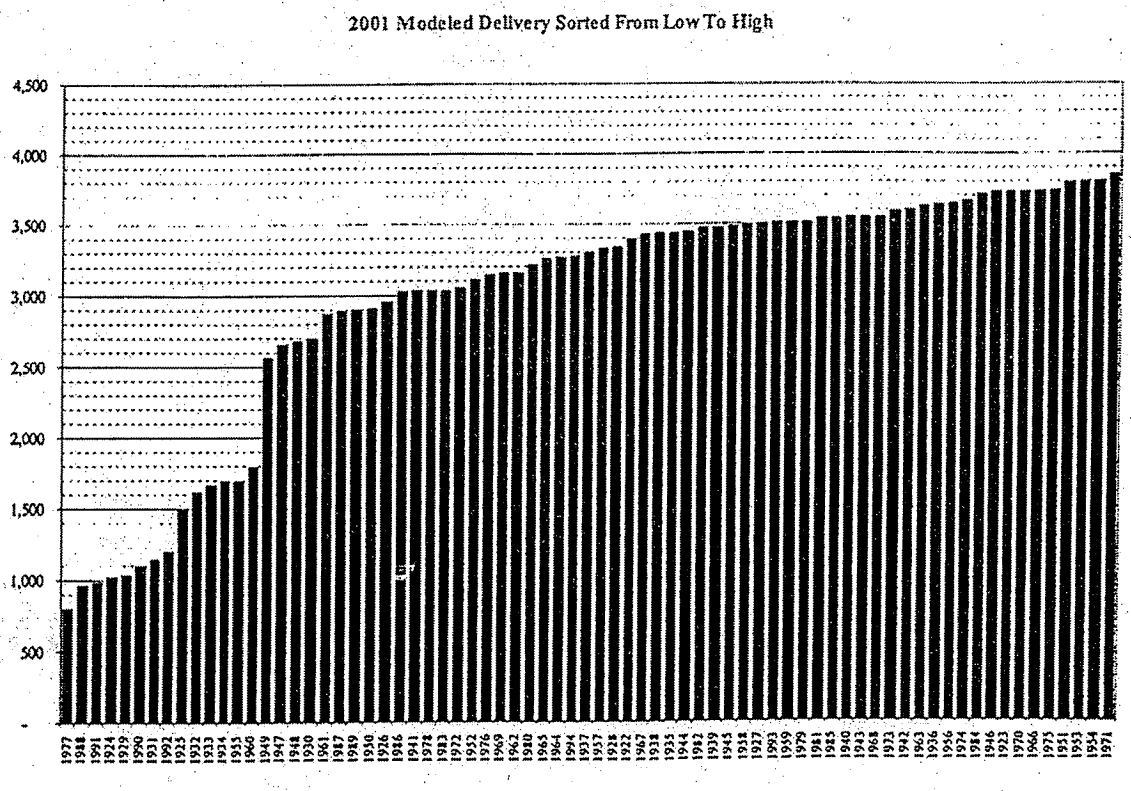
## How Did The Department Estimate The Delivery Probabilities?

To estimate the delivery probabilities, the Department used a model called Calsim II. Calsim II is a complex linear programming model that attempts to mathematically simulate the operations of the SWP and the Central Valley project. To do this, Calsim II has a large set of equations that describe how all the various rivers, dams, canals, diversion points, discharge points, etc. all relate to each other. It has another large set of equations that describe the rules for operating the various water facilities – when to create flood control storage, when to reduce delta exports to meet water quality regulations, etc. Calsim II then associates with these equations data that describe the particular point in time under consideration. For the draft reliability report, those data describe the level of development in 2001 and 2021.

To develop the delivery probabilities, Calsim II is then asked the following question. Assuming all of these relations and conditions for 2001 stay the same, how much water would be available for export from the Delta if, instead of 2001's weather pattern, we had 1922's weather pattern instead. Then, given how full the reservoirs would have ended up after 1922's weather pattern, what would happen if we then we had 1923's weather pattern, 1924's weather, and so on. The following chart shows the Calsim II results for 2001 level of development.




The basis for the delivery probability chart becomes clear when these data are sorted from low to high.



**Why Do People Question the Results?**

People have raised a litany of concerns with the results. Some of these concerns are more valid than others. The major concerns seem to be:

- Recent deliveries were lower than the modeled 2001 conditions.
- 2021 does not seem to reflect any growth in upstream consumptive use.
- Calsim II has not been calibrated, tested, or otherwise verified.
- The results appear inconsistent with previous estimates and models.
- Calsim II is not being used as designed.

Each of these concerns is discussed in turn, with a short assessment of their legitimacy.

**Recent deliveries were lower than the modeled 2001 conditions.**
Chart 1 (attached) shows historic Table A deliveries along with the modeled maximum, minimum, and median level for 2001 conditions. Recall that under 2001 conditions, half the time one would expect to receive more than the median level, half the time less. As Chart 1 shows, not once has the SWP delivered Table A water equal to the median rate. So, many think Calsim II over estimates the SWP's delivery reliability.

Part of the problem is that Calsim II calculates Table A deliveries slightly differently from those reported in Bulletin 132. For example, Calsim II counts water contractors carryover in the year it is created, not the year it is delivered. That is, Calsim delivers water whenever it has the capacity, with no allowance for a contractor's desire to carry water over to the next year. The difference between actual Table A deliveries as reported in Bulletin 132 and as calculated in Calsim II is shown in Chart 2.

Chart 3 shows the actual Table A deliveries, adjusted for how Calsim II treats carryover, along with the modeled maximum, minimum, and median level for 2001 conditions. Once placed on an apples-to-apples basis, the adjusted Table A deliveries still look low compared to the modeled 2001 delivery reliability. Only once do deliveries reach the median rate – the amount the model says would be deliver half the time. And as shown in Chart 4, the picture doesn't change much when Article 21 (surplus) water is included. Recent experience seems lower than modeled 2001 conditions. So, Calsim II continues to look like it overstates the delivery reliability of the SWP.

A strong counter to the argument that Calsim II exaggerates the SWP's reliability would be that the reason the SWP hasn't delivered that much water in the past is because the contractors haven't asked for that much water. However, this doesn't seem to be the case. Chart 5 shows Actual Table A deliveries and contractors requested delivery. As the chart shows, on 9 occasions requests have been higher than the median rate, only once has the median rate been met. In fact, only once in the last 12 years has the SWP been able to deliver 95 percent or more of contractor requests. Again, Calsim II looks like it over estimates SWP reliability.

Nor does water year type seem to explain the discrepancy. Chart 6 is the same as Chart 5, except the water year type (Sacramento River Index) is shown above each

delivery amount. It shows, for example, that 1998 was a wet year, contractors requests were greater than the median rate, yet contractors received only half of their requested amount (as defined by Calsim II).

What the chart does not show, is that because of the heavy snow pack and spring runoff in 1998, the contractors did not want all of the water they had initially requested. They cut their demand, including carryover water, to just under 1.7 million acre feet (maf). However, the modeling didn't foresee this possibility. The modeling assumptions varied demand between 3.0 and 4.1 maf based on weather. The 3.0 maf demand used in the wettest years was well above the 1.7 maf ultimately demanded by the contractors in 1998. This suggests that the modeling assumptions might be part of the reason Calsim II seems to overstate delivery reliability.

While many try to compare the modeled 2001 reliability against historic SWP operations, it is not really appropriate for much of the period. As previously noted, Calsim II assumes there are no changes from 2001 in the physical and operational aspects of the SWP. Yet in the early history of the SWP, many facilities were not constructed. For example, the big pumps at Edmonston Pumping Plant didn't start pushing water over the Tehachapis until 1971. Also, Contractors' contractual claims for delivery as reflected in Table A were greatly diminished in the early years – it wasn't until 1990 that Table A amounts exceeded 4.0 maf. And, regulatory rules governing the Sacramento-San Joaquin Delta have also changed over the years. The current governing rules, D-1641, weren't issued until 1995. Consequently, comparing modeled 2001 reliability against actual deliveries is somewhat misleading much beyond the last few years.

So, lets look at recent years. Following the notion of water year further, Chart 7 is the 2001 modeled delivery, sorted by water year type (Sacramento River Index). This way one can compare recent years to the appropriate water year type reliability. The first thing one notices is that the median level for below normal years is *higher* than the median level for above normal years and is nearly the same as for wet years. Common sense would suggest that the median level in below normal years would be *less* than the level for above normal years. This suggests something odd is going on within Calsim II.

Water year 2001 was classified "dry" and contractors requested Table A deliveries of over 4.1 maf. Chart 8 shows actual 2001 Table A deliveries (adjusted) compared to modeled 2001 dry year reliability. It shows that 2001 deliveries were less than the least amount Calsim II would say would ever be delivered in a dry year. However, one would expect 2001 deliveries to be greater than the lowest dry year. 2001 was not the driest dry year – 1932 was. Also, 2001 followed an above average year, which itself followed five consecutive wet years. Consequently, the beginning storage in 2001 ought to have been much higher than in 1925, which followed the driest year modeled, or 1932, which followed a 3 year period of dry and critically dry years. This is further evidence that Calsim II overstates delivery reliability.

Water year 2000 was classified as "above normal." Chart 9 shows actual 2000 Table A deliveries compared to modeled 2000 above normal year reliability. It shows that 2000

deliveries were above the median for above normal years. This is seems reasonable, and appears to be the exception to the rule.

Water years 1998 and 1999 were classified "wet" and in both years contractors requested more than 3.3 maf. As Chart 10 shows, actual 1998 and 1999 Table A deliveries were again less than the least amount Calsim II would say would ever be delivered in a wet year. In fact, 1998 deliveries were 45 percent less than the lowest modeled delivery. In both years, because of a high snow pack and runoff, contractors did not want the full amount of water they initially requested. However, as noted above, the assumptions behind Calsim II did not consider that contactors might reduce their demand below 3.0 maf. This reinforces the notion that the modeling assumptions might be part of the reason Calsim II seems to overstate delivery reliability

In summary, while a strict comparison of historic Table A deliveries to modeled 2001 delivery reliability suggests Calsim II over estimates the SWP's delivery reliability, such a comparison is misleading. Part of problem is that Bulletin 132 and Calsim II calculate Table A deliveries slightly differently. Another problem is that Calsim II assumes there are no changes from 2001 in the physical and operational aspects of the SWP. Yet as recently as 1995, the Delta's regulatory operations were much different.

Nonetheless, there is still much evidence that suggests there is something wrong with the Calsim II results. For example, the median level for below normal years being *higher* than the median level for above normal years and being nearly the same as for wet years is quite curious.

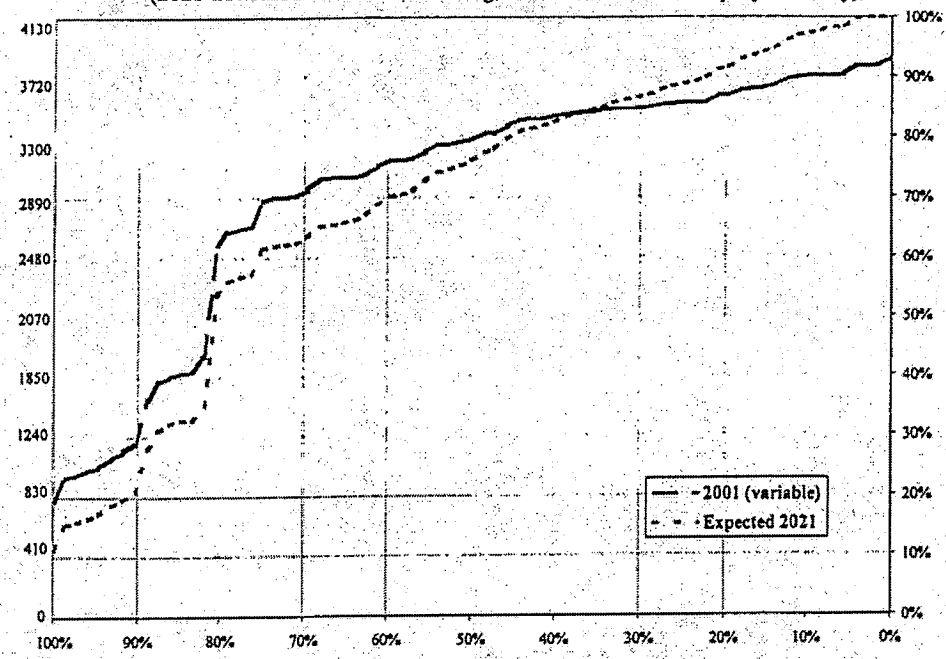
Moreover, much of the evidence that suggests there is something wrong with the Calsim II results indicate that the modeled 2001 results overstate SWP delivery reliability.

- Only once in the last 12 years has the SWP been able to deliver 95 percent or more of contractor requests.
- The 3.0 maf contractor demand used in the wettest years was well above the 1.7 maf ultimately demanded by the contractors in 1998.
- 2001 deliveries were less than the least amount Calsim II would say would ever be delivered in a dry year, despite evidence that it should not have been.

All this implies there is either a problem with Calsim II, its assumptions, or both.

**2021 does not seem to reflect any growth in upstream consumptive use.**
The draft report shows SWP Delta delivery probabilities under 2001 and 2021 levels of development. Presuming that upstream development – and hence consumptive water use – will be greater in 2021 than in 2001, one would expect that during periods of water shortage, less water would be available for export in 2021 than in 2001. This is illustrated below.

**2001 & Expected 2021 Delivery Probablity**
(2021 not based on actual modeling, shown for illustrative purposes only)




However, the chart below from the report shows, for much of the time, the modeling results show *more* water being delivered in 2021 than in 2001. That might make sense during wet periods where the supply constraint would be small, such as when deliveries are at the 0-30 percent level. However, it is particularly troubling in dry periods when water supplies would be particularly tight, such as the 85-80 percent level. So again, the model appears to overstate SWP delivery reliability.

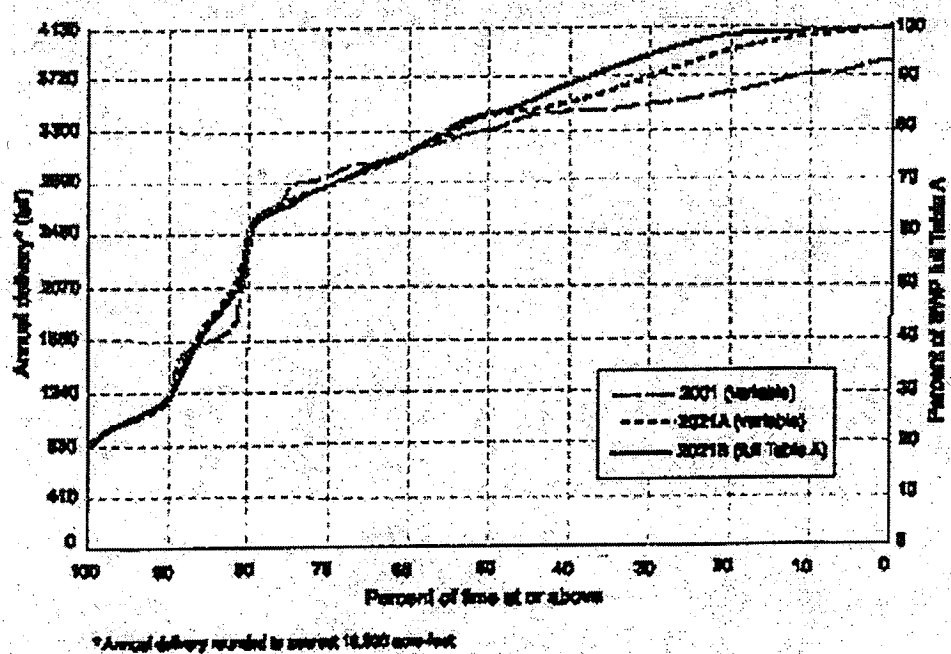



**Figure 1 SWP Delta delivery probability (Table A)**

**Calsim II has not been calibrated, tested, or otherwise verified.**
The Department is releasing this report based on results of a highly complex model that has not been calibrated, tested, or otherwise verified. Calibration is a systematic process of adjusting a model to ensure that the model output accurately matches actual experience. Such adjustments might have to do with changing assumed channel capacity, maximum or minimum water flow rates, reservoir operations, etc. When a model has not been calibrated or otherwise tested or verified, one cannot be sure that the model accurately reflects reality.

This lack of calibration or testing is especially troubling given the many changes made between this model and its predecessor.

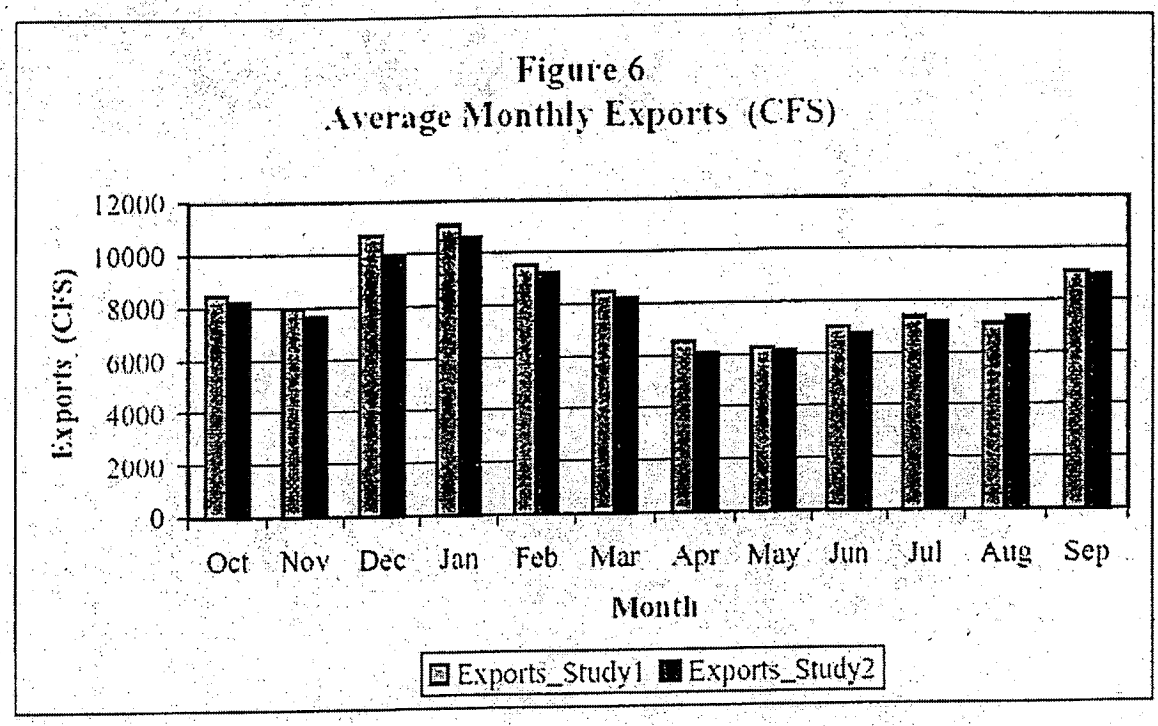
These changes include:

- New logic for determining deliveries to north-of-Delta and south-of-Delta CVP and south-of-Delta SWP contractors;
- New procedures for dynamic modeling of CVPIA 3406(b)(2) water and the Environmental Water Account (EWA);
- Addition of numerous surface streams and control points; and
- Incorporating groundwater into the modeling.

The interaction of groundwater into the modeling is a particular concern. The California Water Plan Update Modeling Workgroup meet last year to get an update on Calsim II. At the meeting, a Department staff person commented on the tendency for Calsim II to pump groundwater without regard to sustainable yield or capacity of the aquifer. That is, Calsim II tended to assume that upstream water users would pump groundwater beyond all practical limits. This might explain why, as discussed in the previous section, additional upstream development in 2021 did not affect dry year delivery reliability – the model might have assumed that more groundwater would be pumped to meet any assumed additional upstream demand. This is another reason why Calsim II appears to overstate SWP delivery reliability.

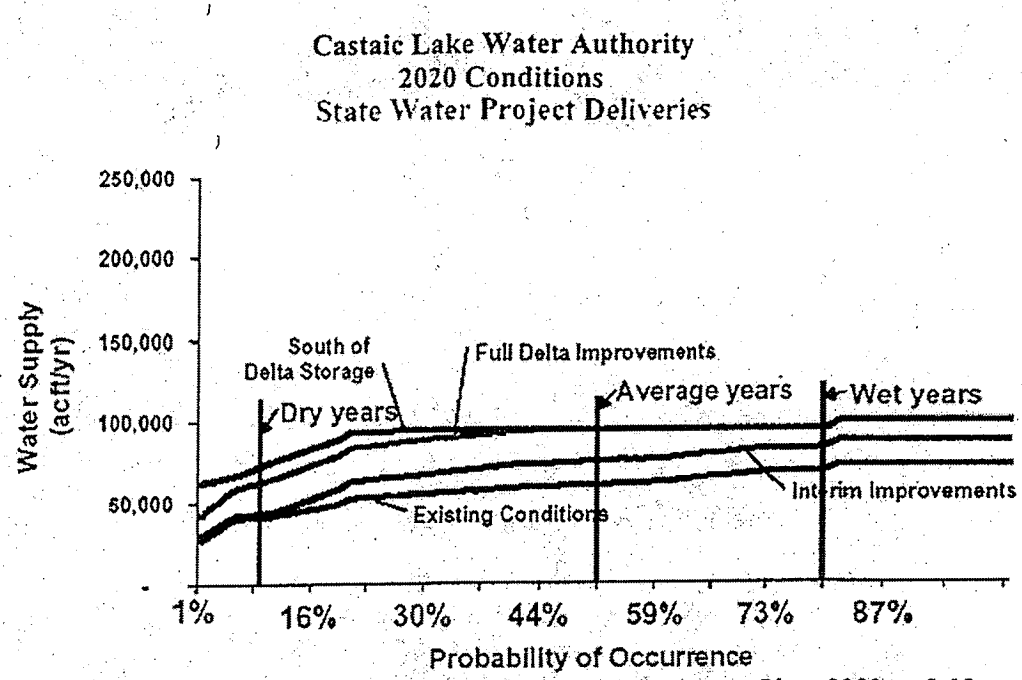
**The results appear inconsistent with previous estimates and models.**
The monthly timesteps used by Calsim II overestimates delta export capacity when compared to the daily timesteps used in DWR Delta Simulation Model (DWRDSM2). As noted in the In-Delta Storage Program's *Draft Report on Operation Studies*.

*The daily fluctuations of inflow above and below the monthly mean cause a diversion pattern that reduces the exports from the Delta as compared to those achieved in the monthly model. This phenomenon is shown in Figure 6, where the monthly average amounts exported by the daily model are shown to be consistently lower than those in the monthly model, except for August. The lower exports inevitably impact on the annual deliveries.*




In Figure 6, reproduced above, the monthly Calsim II results are labeled Exports_Study1 and are the left bar for each month. The daily model results are labeled Exprts_Study2 and are the right bar for each month. The models clearly disagree on export capacity. However, we do not know which model more closely simulates actual export capacity.

Calsim II also shows higher delta export capacity when compared to the results of DWRSIM, the predecessor to Calsim II. Castaic Lake Water Agency, in developing their 2000 Urban Water Management Plan, used DWRSIM, to estimate their SWP delivery reliability. Their analysis showed that under 2020 conditions, with no changes to existing facilities or operating rules, the maximum delivery they could expect would be just over 70% of their maximum Table A deliveries. This is significantly different from the Calsim II results, which show they should expect to receive 100 percent of their maximum Table A deliveries nearly 10 percent of the time. Again, the models clearly disagree on export capacity. However, once again we do not know which model more closely simulates actual export capacity.




Castaic Lake Water Agency. *2000 Urban Water Management Plan*. 2000. p. 2-12.

**Calsim II is not being used as designed.**

Calsim II was designed to answer the following type of question. Given that we have a problem with something, such as meeting delta water quality requirements, would making a specific change to the system, such as adding a reservoir, make the problem better or worse? To answer the question, Calsim II is first set up and run to representing the way the system is currently. This is referred to as the "base" simulation. Then the model is adjusted to represent the specific change under consideration. This is called the "with project" simulation. Then the results of the two simulations are compared to see if the proposed change makes thing better or worse.

Calsim II was not designed to be used to establish absolute levels of exports, as it is in this report. As noted in the *Benchmark Studies Assumptions*:

*It is intended, that CALSIM II be used in a comparative mode. The results from a "With Project" alternative simulation are compared to the results of a "base" simulation, to determine the incremental effects, of a project. The results from a single simulation may not necessarily represent the exact operations for a specific month or year, but should reflect long-term trends. – Benchmark Studies Assumptions, September 30, 2002*

When used in the comparative mode, it is at least possible that any systematic problem with the model would "cancel each other out." This is not the case when used to establish absolute levels of exports, as it was in the draft reliability report.

People are understandably concerned whenever a model is used in a way different from than for which it was designed. This is especially true when the different use of the model has not been rigorously evaluated. Without testing or otherwise verifying Calsim II, it is simply not possible to know whether or not the model's results are reliable when Calsim II is used as it is in the draft reliability report.

**Other Concerns**

The proceeding are the most frequently mentioned concerns with the draft report. However, there are many others. These include:

- The "level of development" estimate was based on the oft-criticized Bulletin 160-98. One of the criticisms about Bulletin 160-98 was that it overestimated urban water demand, including areas upstream of the Delta. Because of these criticisms, the next edition of Bulletin 160 will use a different process for estimating urban water demand. Consequently, the concerns about using the Bulletin 160-98 estimates seem legitimate, though the effect on delivery reliability is uncertain.

- One cannot evaluate the reasonability of SWP delta exports without also looking at the CVP exports. These estimates are not reported and the US Bureau of Reclamation has not done a similar exercise. It is possible that one reason SWP delivery reliability seems high is that the model essentially took water from the CVP and delivered it to SWP. Without seeing the modeled exports for both projects, one simply cannot know.

- The Department's public explanations for why the model is reliable rely solely on the modeling analysis. There has been no outside corroboration of the model results. This is an issue of credibility, and again seems legitimate.

- Calsim II assumes that the system is run "by the book." However, there are numerous examples where the system was not run "by the book" with often significant consequences. For example, 1990 operating decisions "bet" that there would not be another critically dry year in 1991. This lead to disastrous conditions in 1991. While this is a legitimate criticism, it is not certain that the modeling would require some correction. It might be that the operators simply need follow the operating rules to more closely.

- Calsim II does not model curtailments at pumps for exceeding the take limits of endangered species. Yet this occurs somewhat frequently. This might be another reason why delivery reliability appears high.

- Calsim II assumes water delivered any time of year is useful to all contractors. This might be true for Metropolitan Water District of Southern California and the Kern County Water Authority as they have own storage options. This is not true for other contractors such as Santa Barbara County. Again, this might be part of the reason why the modeled delivery reliability seems to have been overestimated.

- Legislature has had credible testimony that the historic weather pattern is no longer a reliable indicator of the future. Yet, the simulation was based entirely on historic hydrology. A shift from snow to more rain predicted by climatologists would have big consequences for delta exports. However, it is not clear that such effects would be noticeable by 2021.

- Recent years are not included in analysis – the simulation ignores 1995-2001. While it might be unrealistic to expect all the data necessary for including 2000 or 2001 to been developed yet, it does seem reasonable to expect data for the 90s to be included.

**Additional Issues That Cause Some Concern**

- At some of the public briefings, the Department's explanations for increased reliability in future the occasionally referred to actions or programs not included in modeling; such as increase regulatory limits on exports or new facilities. Yet, such changes were not a part of the analysis, so those changes could not be part of the reason for higher delivery reliability.

- Much of the data are of poor quality – especially for groundwater effects. If you don't think the model inputs are accurate, it is difficult to accept that the model outputs are accurate.

- Calsim II is a linear model used to simulate what looks to be a non-linear system. This suggests the model is misspecified, with difficult to predict consequences.

- Department did not take testimony in public – public cannot hear others' concerns about the report before they submit their comments.

- Typos – Table B-3, column labeled "model variable demand" shows average 3712. Average of column is in fact 3709. All the data in the report need double checking.

**Why is this a problem?**

Many agencies will use the SWP Delivery Reliability report for many purposes. In addition, Calsim II is the basis for many water program analyses.

- Local water agencies will use the reliability report for local planning purposes, such as developing the Urban Water Management Plans required by Water Code Section 10610. Efficient local planning requires credible estimates of SWP reliability.

- Local agencies will also use the report to comply with the requirements of SB 221 and SB 610. These laws require water retailers to certify there is sufficient water to meet the requirements of new development projects.

- The California Water Plan Update plans to use Calsim II to describe the State's water conditions. The California Water Plan is to guide the strategic development of the State's water resources.

- Calfed is using Calsim II as part of its integrated storage investigations. The result of these investigations will be recommendations for potential new water supply projects.

- All of these investigations will be used to justify future statewide water bonds

However, if the delivery reliability of the SWP is overstated and Calsim II results are questionable, the consequences would be significant.

- Local agencies will mis-size local water projects.
- Local development could be hampered if, when complying with SB 610 and SB 221 or CEQA, there are significant disputes over current and future water supplies.
- The California Water Plan would once again be subject to widespread criticism.
- Conclusions of Calfed's Integrated Storage Investigation (ISI) will be suspect given that the same model is used in both the ISI and the SWP Reliability report.
- Future statewide bonds for increasing water supply will be in jeopardy, if opponents can credibly challenge the underlying analysis.

**Solutions**

As the Bay-Delta Modeling Forum's Ad hoc Modeling Protocols Committee noted in their *Protocols for Water and Environmental Modeling:*

*In the highly technical and political arenas of California water, it is important that models enjoy a wide base of support from stakeholders and decision-makers, technical staff, and even the public. Modeling of water systems is not just a technical exercise. The objectives of modeling are to aid in planning, policy or operational decisions. Thus, models must be developed and used in ways that (1) provide assurance to decision-makers that the analysis is reasonable, (2) can be trusted by reasonable parties, and (3) addresses major technical concerns for the system's performance. – Protocols for Water and Environmental Modeling, January 21, 2000, p. 5*

Unfortunately, Calsim II as used in the draft SWP Delivery Reliability report fails these requirements. While some of the issues raised about the report are misplaced, there are still a significant number of legitimate concerns.

Department's plan to hold peer review, historic simulation, and sensitivity analysis of Calsim II is a good start toward restoring confidence, though there are some concerns.

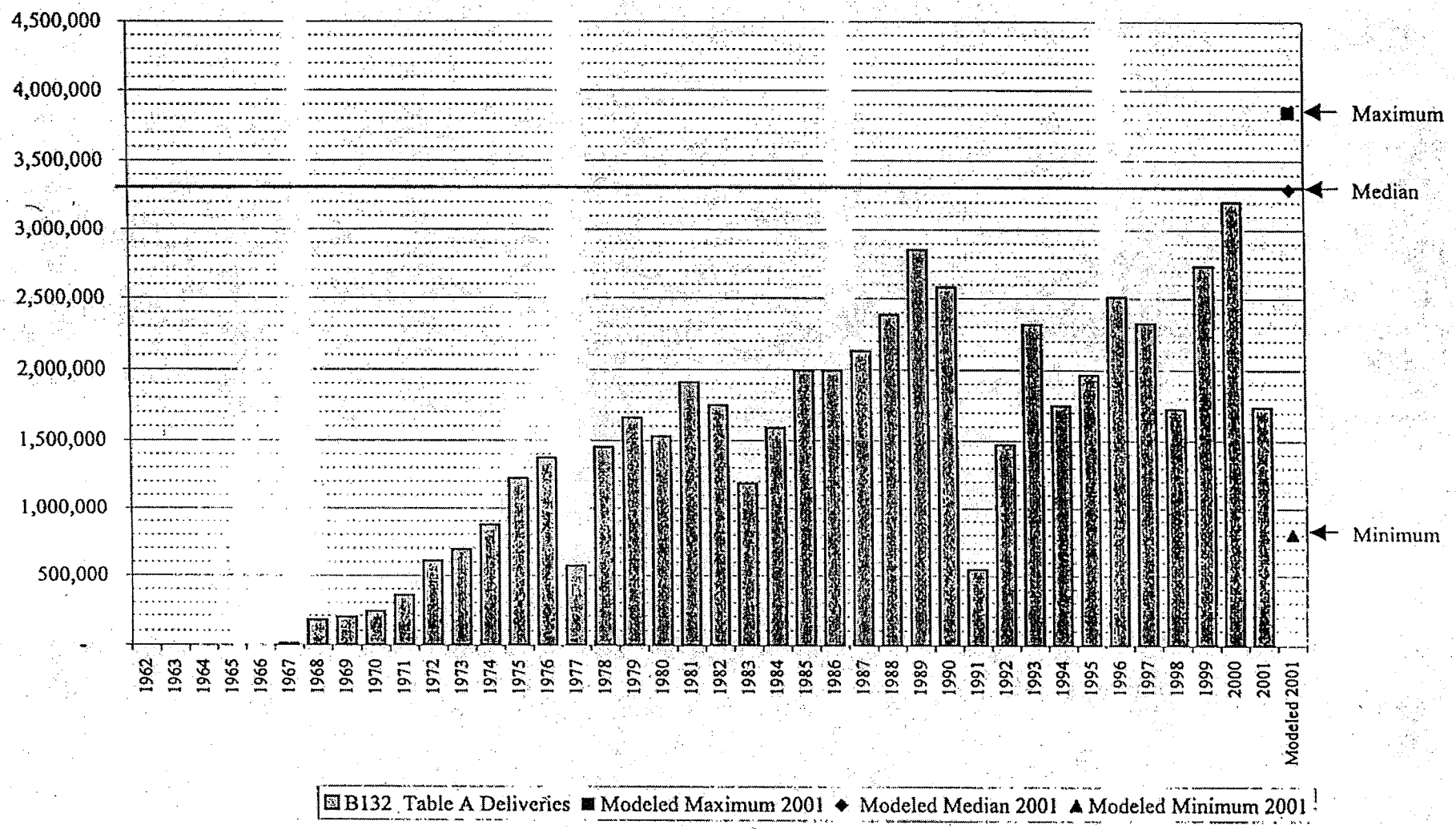
- The peer review etc. will only suggest whether there is something structurally wrong with the model or its logic. It is possible that the model is properly designed, but the underlying data and assumptions are in error, leading to questionable output. The peer review will not show this.
- There is concern about simulating the recent past. Each year's estimate will explain only itself – results for one year do not necessarily imply anything about the accuracy of any other year. In statistical terms, it is equivalent to having zero degrees of freedom.

- It is unclear what the standard or threshold for acceptance or rejection of current model approach is. This will need to be clearly stated before the testing process begins.

It is critical that this report's conclusions have widespread support. Unless and until the Department makes a concerted effort to resolve the concerns of the report's critics to the critics' satisfaction, the report seems premature. From a public policy perspective, it is better not to issue a final report, than to have a final report subject to significant dispute.

Char

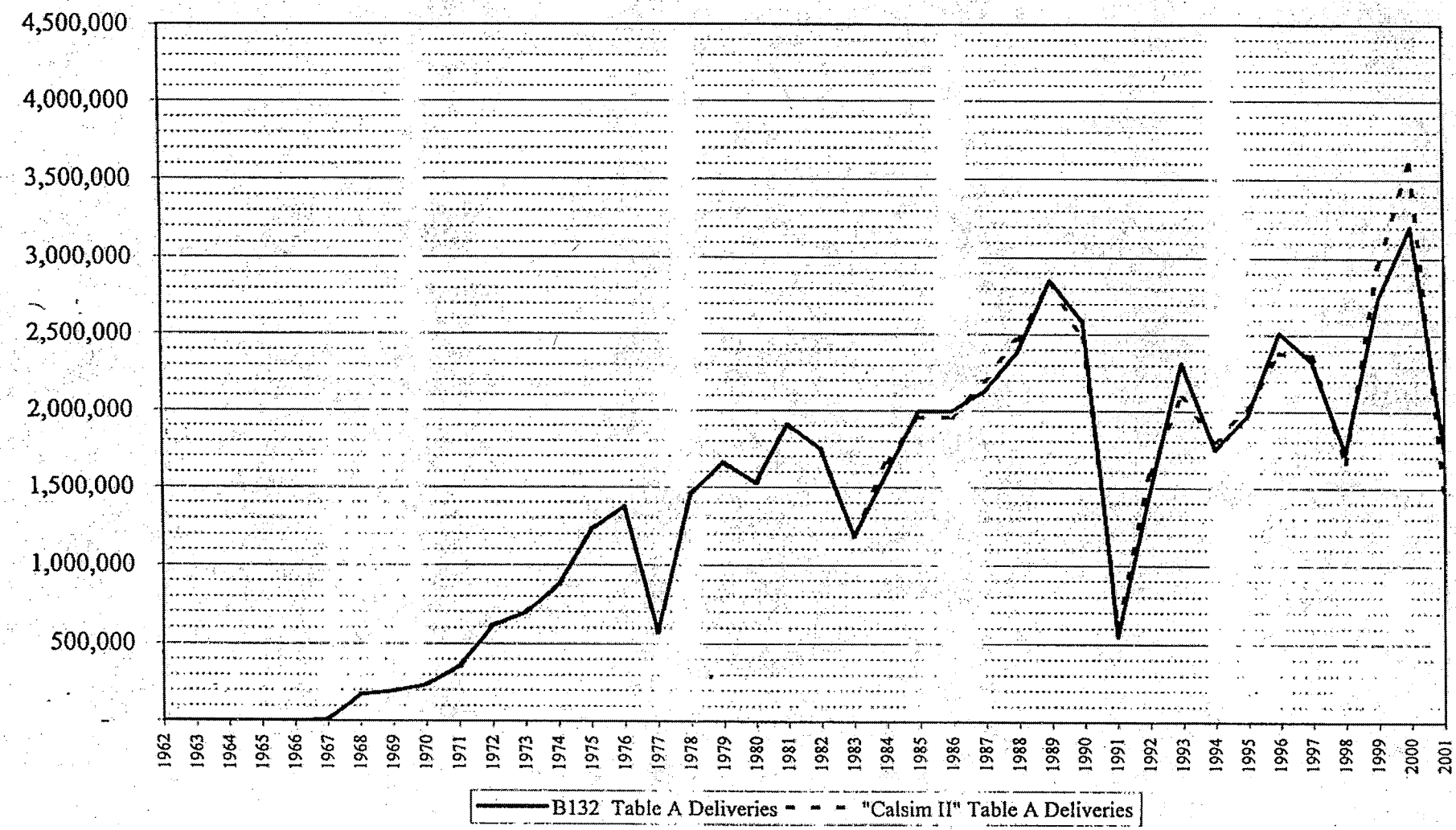
**Compared To Historic Table A Deliveries,**
**The Modeled 2001 Delivery Reliability Looks High**
(Not once do deliveries reach the median delivery rate)




Entitlement Deliveries
(Bulletin 132-00, Table 9-4 Draft Reliability Report, Appendix D)

Cha

**The Difference Between Actual Table A Deliveries**
**As Reported In Bulletin 132 And As Calculated In Calsim II**
(Eg., CalSim II counts carryover water in the year it is created, not the year it is delivered)




Entitlement Deliveries as reported in B-132 and as calculated in CalSim II
(CalSim II deliveries calculated per e-mail conversation with Frances Chung)

Chart 3

**Still, The Actual Table A Deliveries (Adjusted) Look High Compared To The Modeled 2001 Delivery Reliability**
(Only once do deliveries reach the median rate)

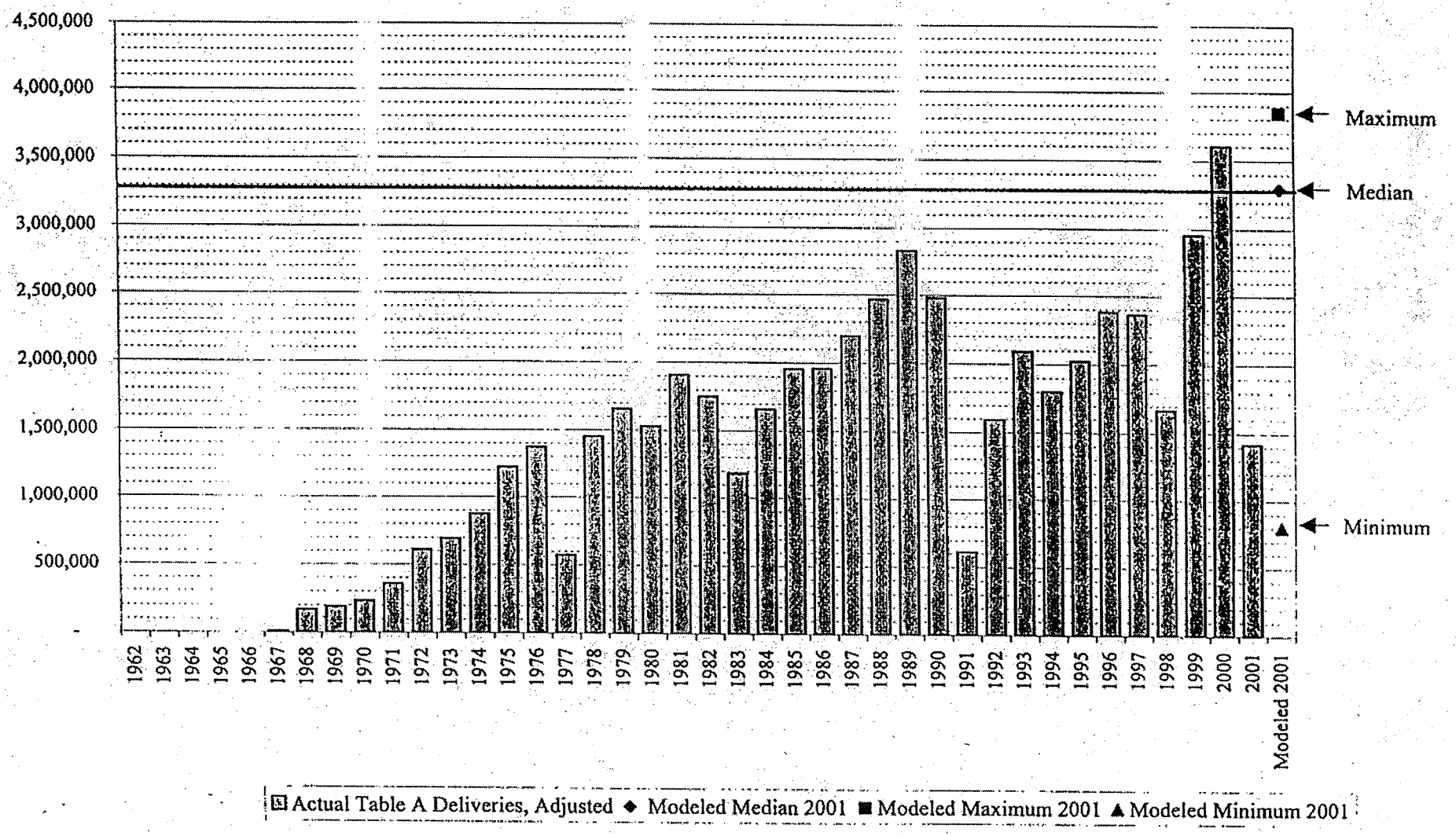


Chart 4

**The Same Picture Holds When Including Article 21 (Surplus) Water**
**Modeled Deliveries Look High Relative To History**
(Only once do deliveries reach the median rate)

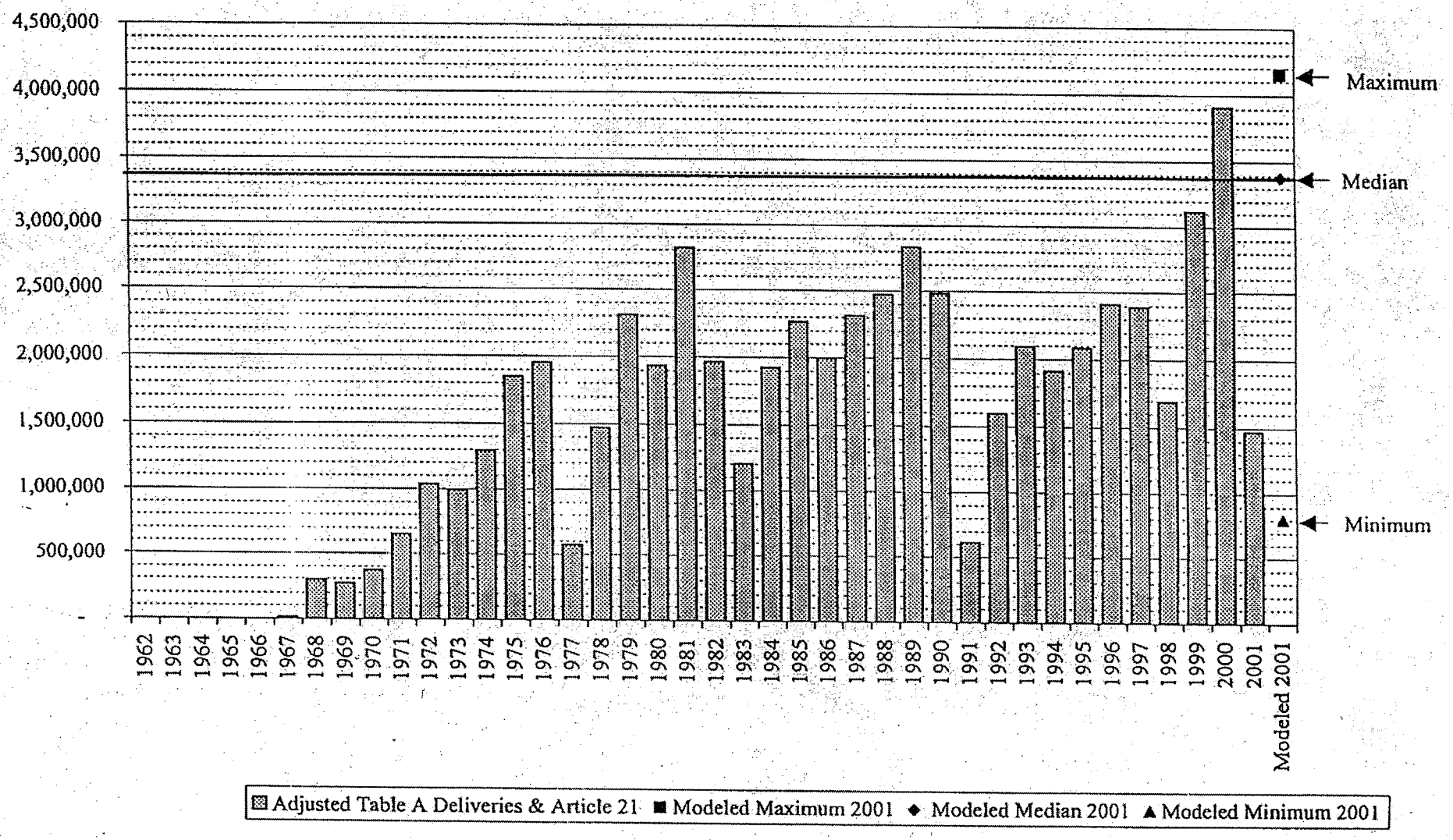
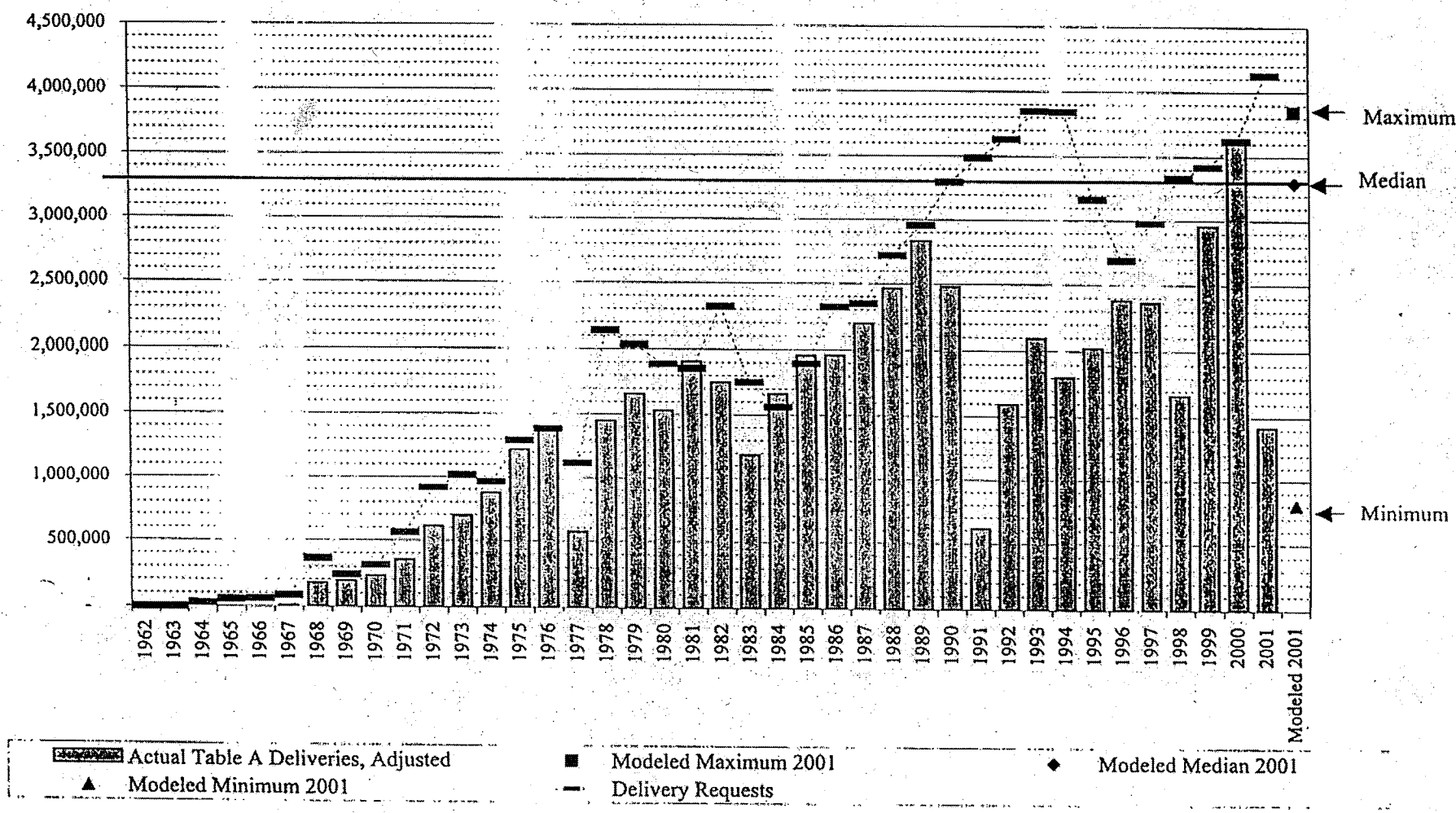


Chart 5

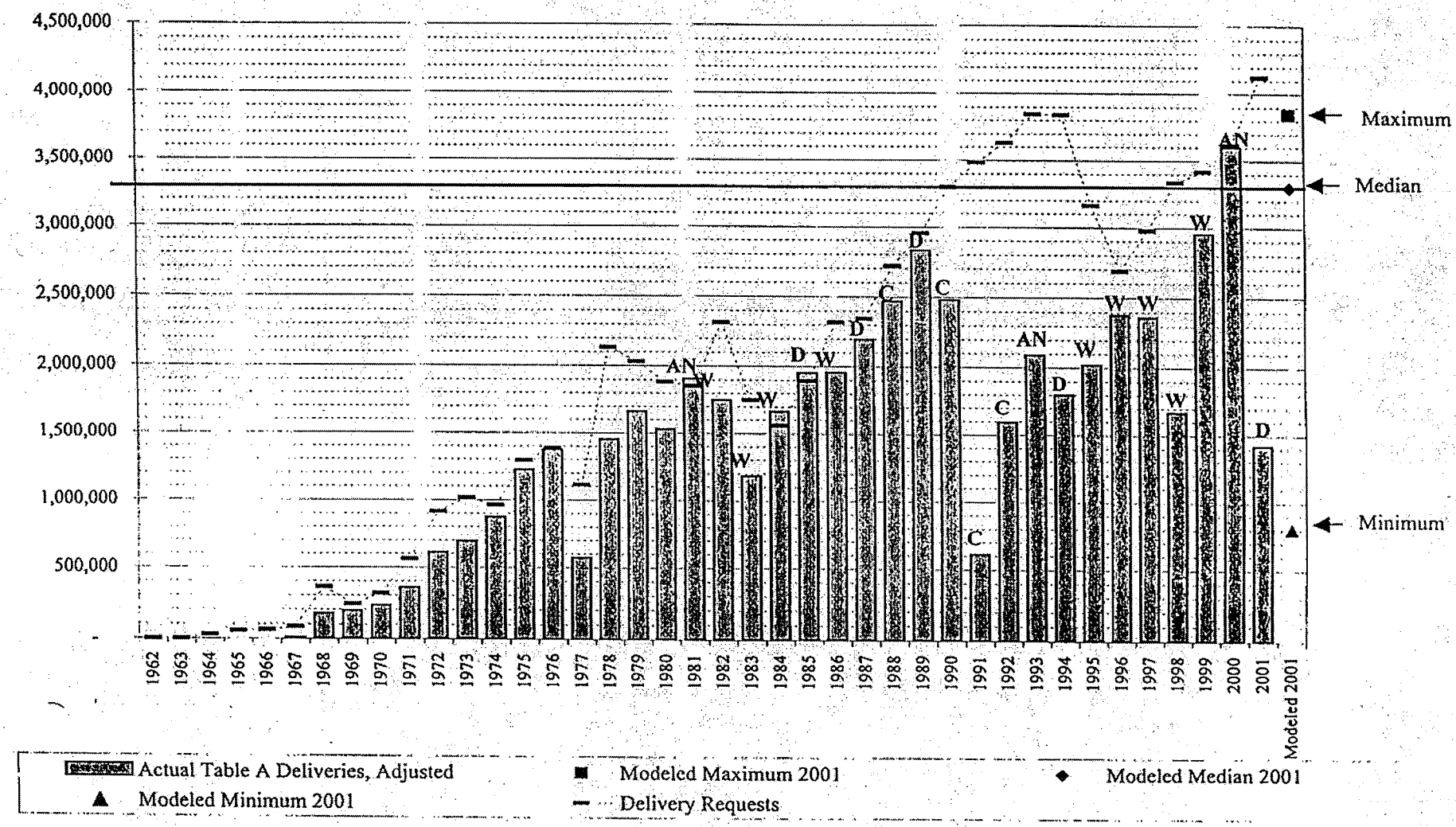
**The Apparent Discrepancy Between Historic Deliveries And Modeled Reliability Doesn't Seem To Be An Issue Of Demand Vs. Capacity**

(9 times requests have exceeded the median rate, only once has the median rate been exceeded)




Source for Requests: Frances Chung and spot checked against B132 various years

**Nor Does Water Year Type Seem To Explain The Discrepancy**
(Eg., 1998 was a wet year, requests were greater than the median rate,
yet contractors received only half of their requested amount (as defined by Calsim II) )



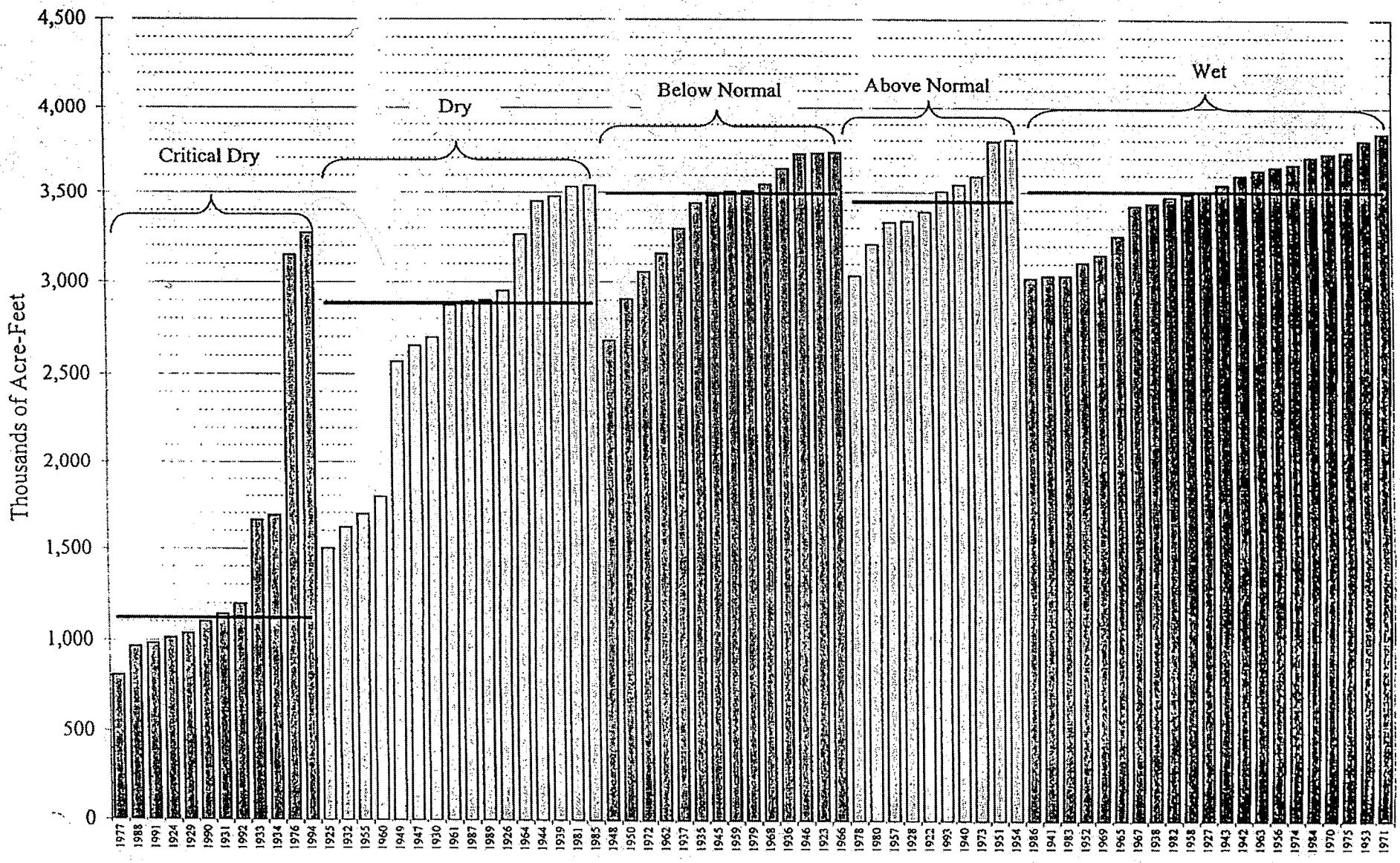

Water year type based on the Sacramento River Index
W -- Wet AN -- Above Normal BN -- Below Normal D -- Dry C -- Critically Dry

**Chart 7**

**2001 Modeled Reliablity Curves Sorted By Water Year Type**

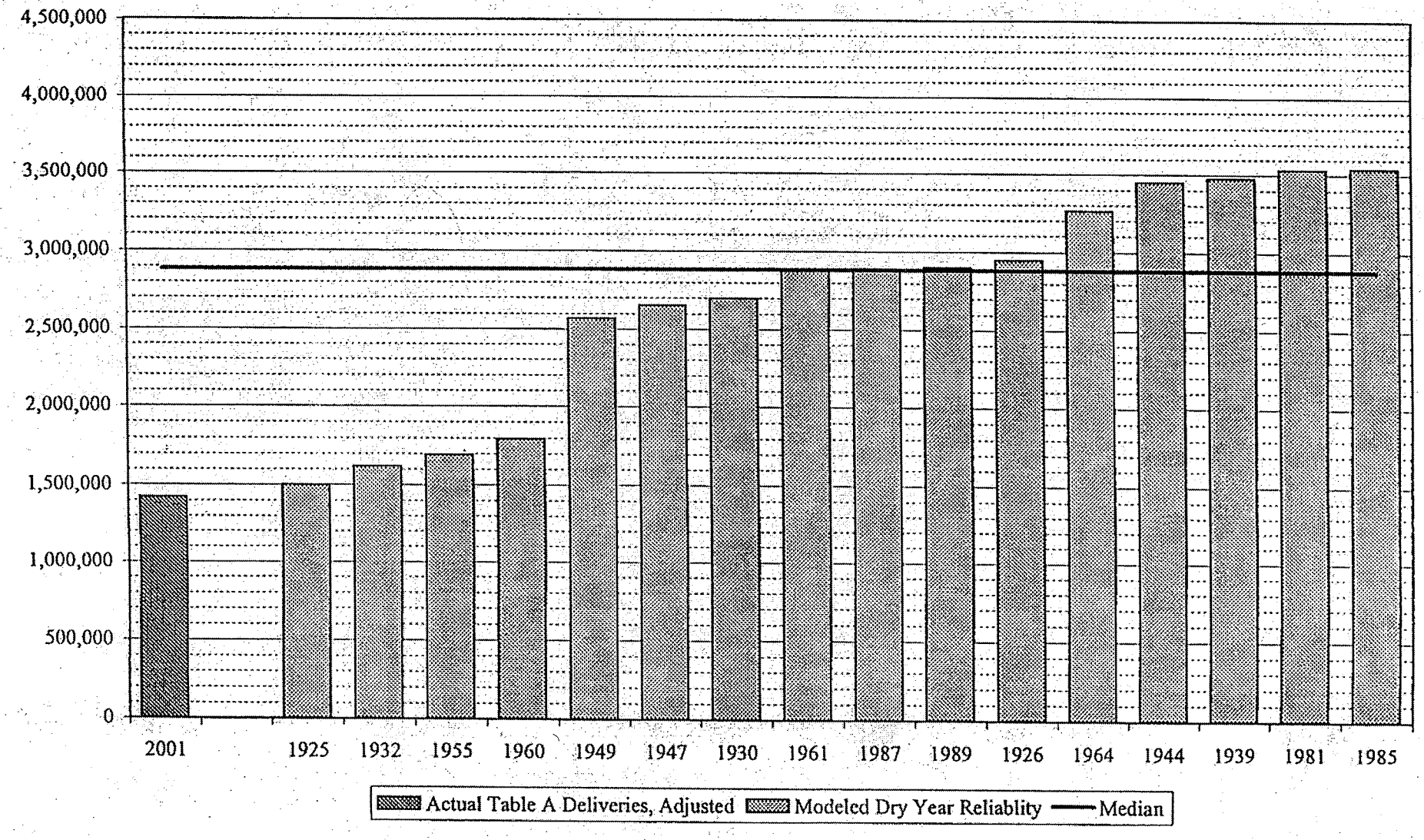
**Show The 50 Percent Exceedence Rate Is *Higher* In Below Normal Years Than In Above Normal Years**

(Bold line shows the 50 percent exceedence rate for each water year type)




(Table B-3 "Model Delivery" grouped by Sacramento River Index water year type)

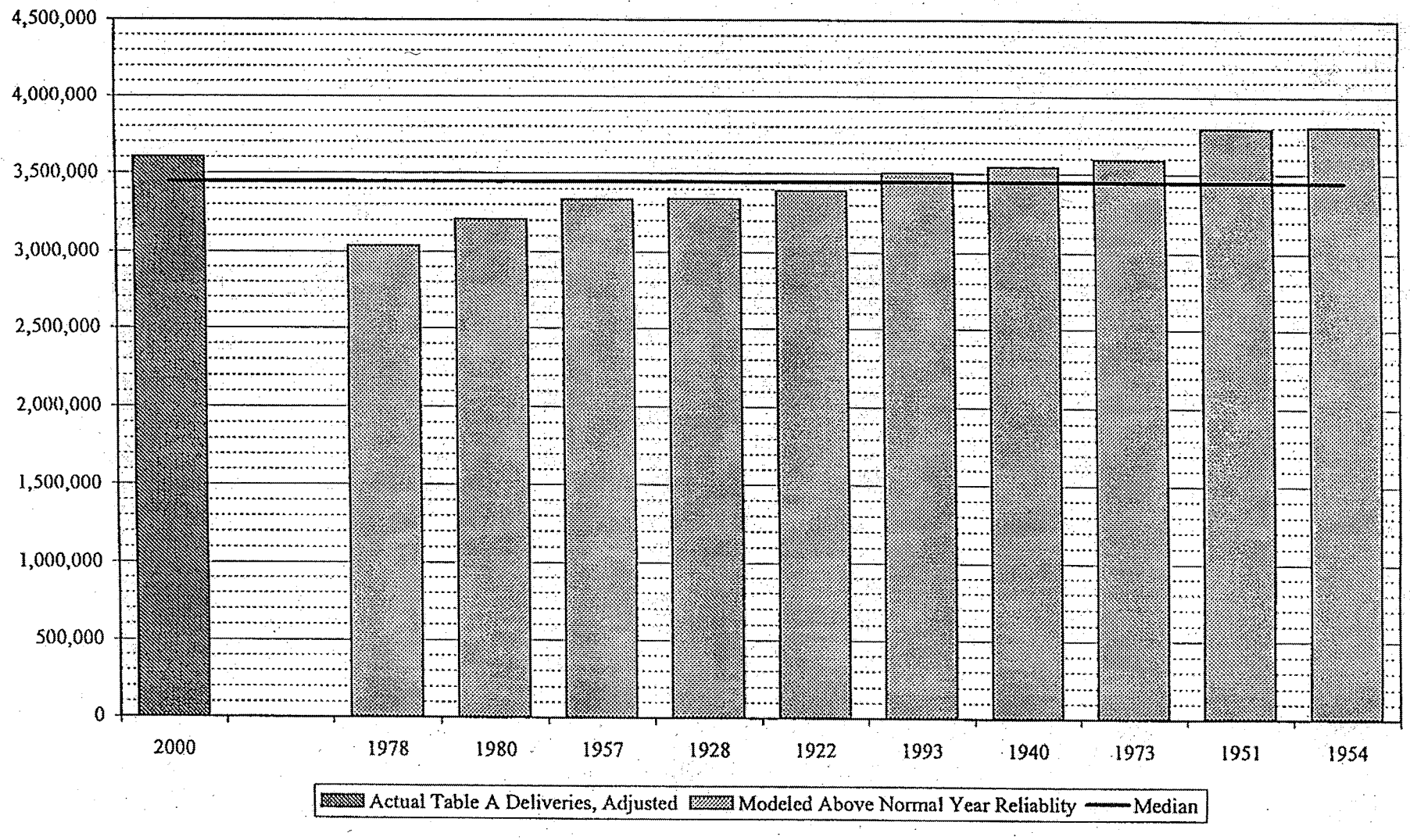
**Looking Only At Dry Years, Actual 2001 Table A Deliveries Were Less Than The Least Amount The Model Says Would Ever Be Delivered**




(Table B-3 "Model Delivery" for Sacramento River Index "dry" years)

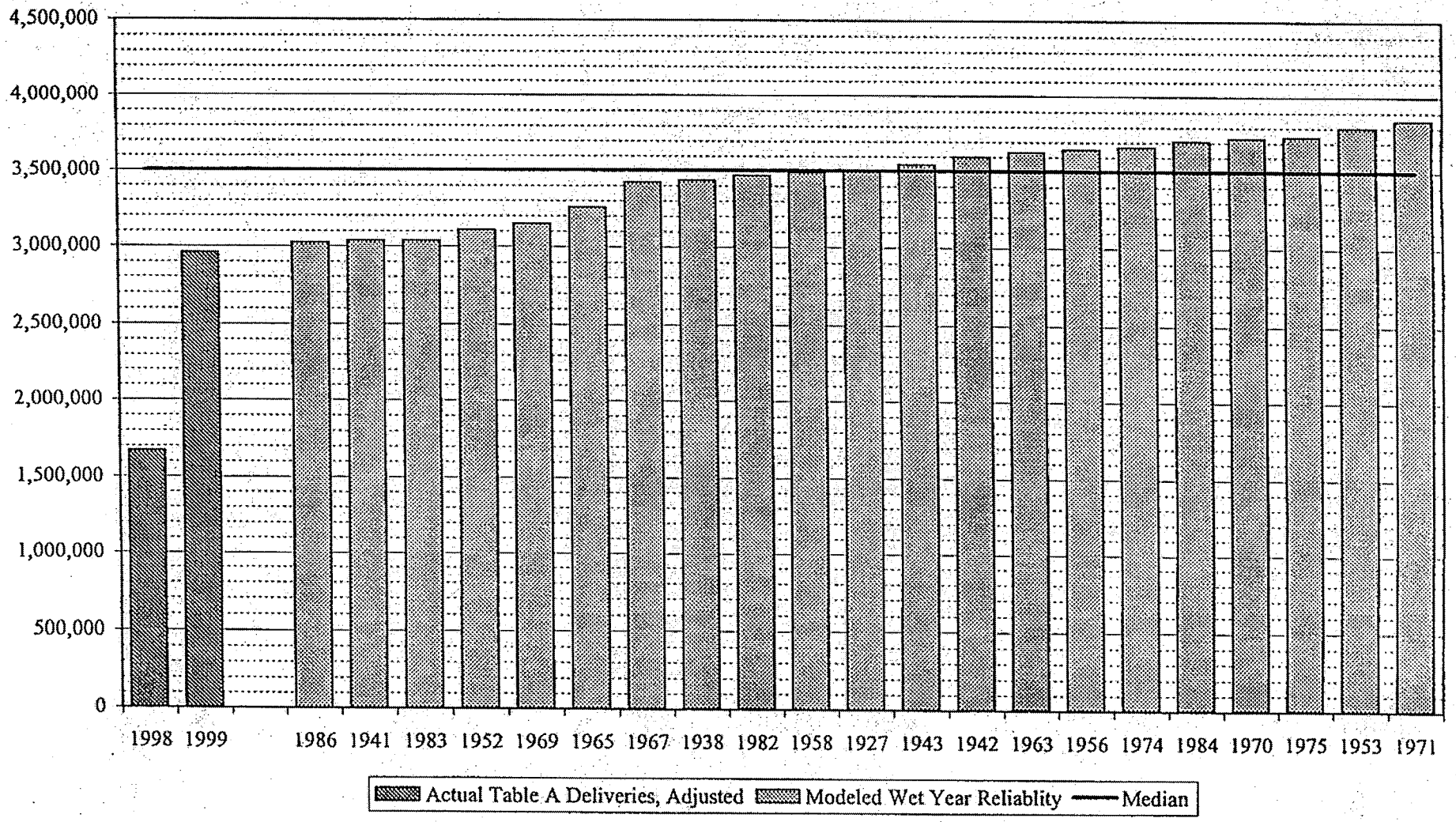
Chart

**Looking Only At Above Normal Years, Actual 2000 Table A Deliveries Were Above The 50 Percent Exceedence Level**




(Table B-3 "Model Delivery" for Sacramento River Index "above normal" years)

**Looking Only At Wet Years, Actual 1998 & 1999 Table A Deliveries Were Less Than The Least Amount The Model Says Would Ever Be Delivered**
(1998 was 45 percent lower than the "least" amount)




(Table B-3 "Model Delivery" for Sacramento River Index "wet" years)

Attachment 25

STATE OF CALIFORNIA -- THE RESOURCES AGENCY

GRAY DAVIS, *Governor*

**DEPARTMENT OF WATER RESOURCES**
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

March 11, 2003

Honorable Michael J. Machado
Member of the Senate
State Capitol, Room 3086
Sacramento, California 95814

Dear Senator Machado:

This is in response to your letter regarding Mr. Dennis O'Connor's comments on the Draft State Water Project Delivery Reliability Report.

Mr. O'Connor's comments describe five major concerns with the report and include miscellaneous observations and comments. The five concerns are:

1. Recent deliveries are lower than the modeled 2001 conditions.
2. The Year 2021 studies do not seem to reflect any growth in upstream consumptive use.
3. CALSIM II has not been calibrated, tested or otherwise verified.
4. The results appear inconsistent with previous estimates and models.
5. CALSIM II is not being used as designed.

In the draft report, the Department commits to an evaluation of the adequacy of using CALSIM II for estimating SWP delivery ability. This effort is underway and consists of the simulation of a recent drought period (1987-1992), a simulation of a longer historic period, a sensitivity analysis of the key parameters of CALSIM II and a peer review conducted by the CALFED Science Program. The entire evaluation is expected to be done within a year. The simulation of the recent drought is complete. The results of this analysis are included in the following discussion of the concern that recent deliveries are lower than the modeled 2001 conditions. The remaining four major concerns are also discussed in the following text. Other comments contained in Mr. O'Connor's report are addressed in Attachment 4.

<u>Recent deliveries are lower than the modeled 2001 conditions.</u>

This concern is expressed in several letters the Department of Water Resources received commenting on the draft report. The thrust of the concern is that the study results contained in this report for State Water Project deliveries are much higher than the amounts of water delivered by the SWP in the past and are, therefore, not accurate or reliable.

Recent amounts, as well as many historical SWP delivery amounts, are lower than the amounts estimated by the 2001 study. This occurs because the 2001 study is a projection of deliveries under year 2001 conditions. SWP contractors' requests for water have increased in recent years, and 2001 is the first year that contractors' requests exceeded 4.0 million acre-feet. Since the 2001 model study includes water demands that are significantly higher than historical levels, modeled water deliveries often exceed historical deliveries. The demands assumed in the model simulations serve as the upper limit for SWP deliveries. The simulation will export as much as allowable to meet the assumed demand; therefore, during wet times, the amount of deliveries is often controlled by the assumed demand. During dry periods, the assumed demands do not control the amount of delivery because water supply is the limiting factor. A good way to analyze how well CALSIM II simulates water system operations is to compare the results of the 2001 study to a recent dry period.

A comparison of adjusted historical and CALSIM II deliveries for the 1987-1992 dry period is shown on Attachment 1. It illustrates that the simulated values for deliveries in the draft report are significantly lower than the historical average deliveries; however, when the CALSIM II study is adjusted to reflect key conditions existing during that period, the resulting average delivery value is slightly lower (50,000 acre-feet per year) than the historical average delivery.

Rather than over-estimating deliveries, CALSIM II appears to slightly underestimate deliveries during periods when water supply is low. This is an important conclusion that should help improve general confidence in using CALSIM II as an analytical tool.

<u>The Year 2021 studies do not seem to reflect any growth in upstream consumptive use.</u>

The model does account for growth in upstream consumptive use as well as other factors affecting river flows. For the modeling of upstream consumptive use, the Sacramento Valley is divided into seven hydrologic units known as depletion study areas. The average total modeled depletion for the 7 areas is 4,749 taf/yr for the 2001 study and 4,875 taf/yr for the 2021A study, an increase of 126 taf/yr. This average increase in depletion is projected to be offset on an average annual basis by an increase in precipitation-runoff of 145 taf/yr attributed principally to increased runoff from urbanization. In addition, average annual net groundwater extraction is projected to increase by 61 taf in the 2021A study compared to 2001 study. Attachment 2 and Tables 1 through 4 in Attachment 4 provide additional information on land use estimates and modeled depletion, precipitation-runoff gain and groundwater pumping for the 2001 and 2021 studies.

CALSIM II has not been calibrated, tested or otherwise verified.

DWR continually checks CALSIM II to determine if it reasonably simulates water operations in the Sacramento – San Joaquin River system. Often this is done with the Bureau of Reclamation during the normal course of business and in coordination with interested stakeholders. The study comparing historical deliveries with modeled deliveries for 1987-1992 is an example of a check that can be done. Rigorous calibration techniques can be applied to only a few components of CALSIM II. Additional discussion of this concern is contained in Attachment 3.

The results appear inconsistent with previous estimates and models.

Mr. O'Connor cites two examples related to estimations of the delivery ability of the SWP and state that these are inconsistent with the studies used in the report. The first is a comparison of CALSIM II with a model using a daily time-step. CALSIM II uses a monthly time-step. The other refers to values contained in the Urban Water Management Plan (2000) for Castaic Lake Water Agency that are based upon DWRSIM, a predecessor to CALSIM II.

The results of the daily time-step are different than the CALSIM II results and the observation is made that it is unknown which model more closely simulates actual export capacity. The choice of the analytical tool depends upon the purpose of the analysis. A daily time-step may be useful in certain circumstances where daily level of detail is important. In other cases, it may not be appropriate. A daily time-step model requires computations to be done for each day of the period of concern. If applied over the entire 73-year period, it requires data be developed for each day of every year, whether the data exists or not. For example, assumptions must be made about the distribution of flows throughout a month to generate assumed daily flows. A monthly time-step model may be the most practical tool to analyze long-term trends and averages; however, it may describe the system in a way that implies the system is more manageable than it actually is.

DWR estimated the impact that a daily time-step can have upon the Delta exports estimates of CALSIM II. The initial modeling work using a daily time-step was done for the In-Delta Storage investigations. For the IDS study, a daily time-step Delta operational model was developed to assess the impact of daily variations on the balance of Delta outflow and the Central Valley Project and SWP exports. The net impact to the exports was sensitive to several other assumptions and resulted in a long-term annual average reduction of 100 to 200 taf/yr for the CVP and SWP combined. DWR is continuing to study the effect of the daily time-step upon long-term studies.

Regarding the 2000 Urban Water Management Plan for Castaic Lake Water Agency, DWR understands that the plan incorporates a more conservative interpretation of the results of the referenced DWRSIM study. DWR supports and encourages local water agencies to apply the level of SWP reliability they determine is appropriate for their areas, taking into account local supplies, other imported supplies, demand-management programs and local planning criteria. The SWP Delivery Reliability Report should serve as a reference document to help clarify decisions that are made at the local level.

CALSIM II is not being used as designed.

This comment relates to the fact that CALSIM II studies are best used as comparative studies. Although analyses based upon stand-alone studies are less certain than analyses using comparative studies, stand-alone studies provide very useful information. For example, DWR routinely uses stand-alone studies to develop strategies for operating the SWP. This process involves technical judgment and knowledge of key elements of the water system. This is the same process DWR encourages local water and planning agencies to take when applying the results in the report.

Your letter, as well as all others commenting on the draft report and the corresponding responses, will be included in an appendix to the final report. In addition, they will be posted on the State Water Project Delivery Reliability Report website (http://swpdelivery.water.ca.gov) this April.

Thank you for your comments and observations. If you wish to discuss these responses further, please contact me at (916) 653-7007 or your staff may contact Francis Chung, Chief of DWR's Bay-Delta Office Modeling Support Branch, at (916) 653-5924.

Sincerely,

*Thomas M. Hannigan*

Thomas M. Hannigan
Director

Attachments

cc: (See attached list.)

Mr. Dennis O'Connor, Consultant to
Senate Committee on Agriculture and
Water Resources
State Capital, Room 406
Sacramento, California 95814

Ms. Jennifer Ruffulo
Research Program Analyst
California Research Bureau
900 N Street, Suite 300
Sacramento, California 95841

## Comparison of Historical and CALSIM II Deliveries for 1987-1992

As explained on page 6 of the draft report, past deliveries cannot accurately predict future deliveries. There have been continual, significant changes in the factors that determine State Water Project water delivery, including water demand. SWP water contractors' requests for water have increased in recent years and 2001 is the first year that requests exceeded 4.0 million acre-feet (as shown in the attached Figure 1).

The 2001 model study used for the draft report assumes that current water-use conditions, including water demands, exist for each year analyzed in the 73-year model study. Since the 2001 model study includes water demands that are significantly higher than historical levels, modeled water deliveries often exceed historical deliveries. One exception to this would be during dry periods because supply, not demand, determines the amount of water delivery.

Historical values for SWP Table A deliveries from the Delta have been compared to the Table A delivery values of the 2001 model study for the dry period of 1987 through 1992 to assess how well CALSIM II simulates supply-limited conditions for a recent period. This comparison requires three adjustments to be made for the results to be comparable. One adjustment is made to the historical delivery data and two are made to the conditions assumed for CALSIM II.

The historical delivery data are adjusted to be comparable to the model results as follows. Historically, a portion of the annual water allocation is carried over in SWP storage facilities and delivered in the following year. The CALSIM II model does not currently have criteria and procedures to allow carryover of allocated water from one year to the next. To make the historical data comparable to model data, the historical Table A delivery data was adjusted to show all the "carryover water" being delivered in the year of allocation rather than the following year. The adjusted historical and 2001 model study deliveries for the 1987 through 1992 dry period are compared in Figure 2.

The modeled average delivery for this period is 1,670 taf/yr compared to the historical average of 2,030 taf/yr in CALSIM II format.

The two adjustments made to CALSIM II are 1) changing the regulatory requirements for Delta operation to match the ones in place during 1987-92, and 2) adjusting the reservoir storages at the beginning of the period to match those that actually existed at that time.

The 2001 model study in the draft report includes regulatory constraints that were not applicable to the 1987-1992 period (State Water Resources Control Board Decision 1641). For comparison purposes, a special 2001 model study was completed with the regulations that were in effect at that time (Decision 1485). As shown in Figure 3, this study produces higher SWP deliveries than the original study with the D-1641 constraints. The study's modeled average delivery for this period is 1,910 taf/yr,

compared to the average of 1,670 taf/yr for the original study. A comparison of the revised study results with the historical deliveries is shown as Figure 3.

Modeled SWP demand for 1986, a wet year just before the dry period, is 3,345 taf compared to the historical request of 2,364 taf. As a result of this higher model demand, modeled SWP storage at the beginning of the dry period is approximately 420 taf lower than the historical SWP storage. The modeled storage at the end of the dry period is essentially the same as the historical value. There is, therefore, an additional 420 taf of supply that would have been delivered in the model and the CALSIM delivery amounts during the dry period should be adjusted accordingly. To adjust for the 420 taf difference in storage, 70 taf was added to the modeled delivery for each of the six years in the dry period. This adjustment raises the average model delivery for the dry period to 1,980 taf/yr, 50 taf/yr lower than the historical average of 2030 taf/yr (Figure 4).

**Figure 1**
**SWP Contractor's Table A Request versus 2001 Model Study SWP Table A Demand**

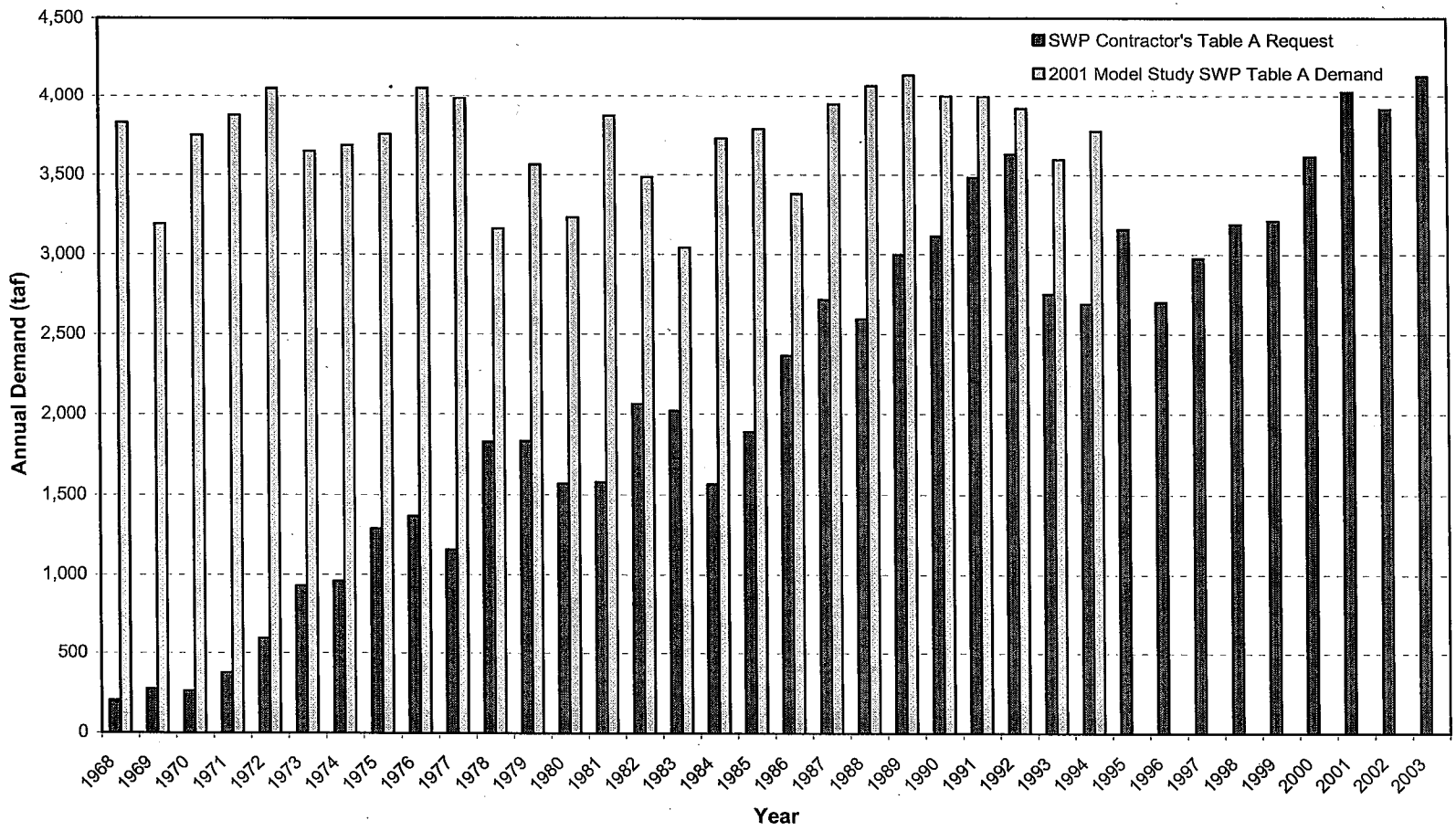


**Figure 2**
**Historical SWP Table A Delivery versus 2001 Model Study SWP Table A Delivery**
***1987 - 1992 Dry Period***

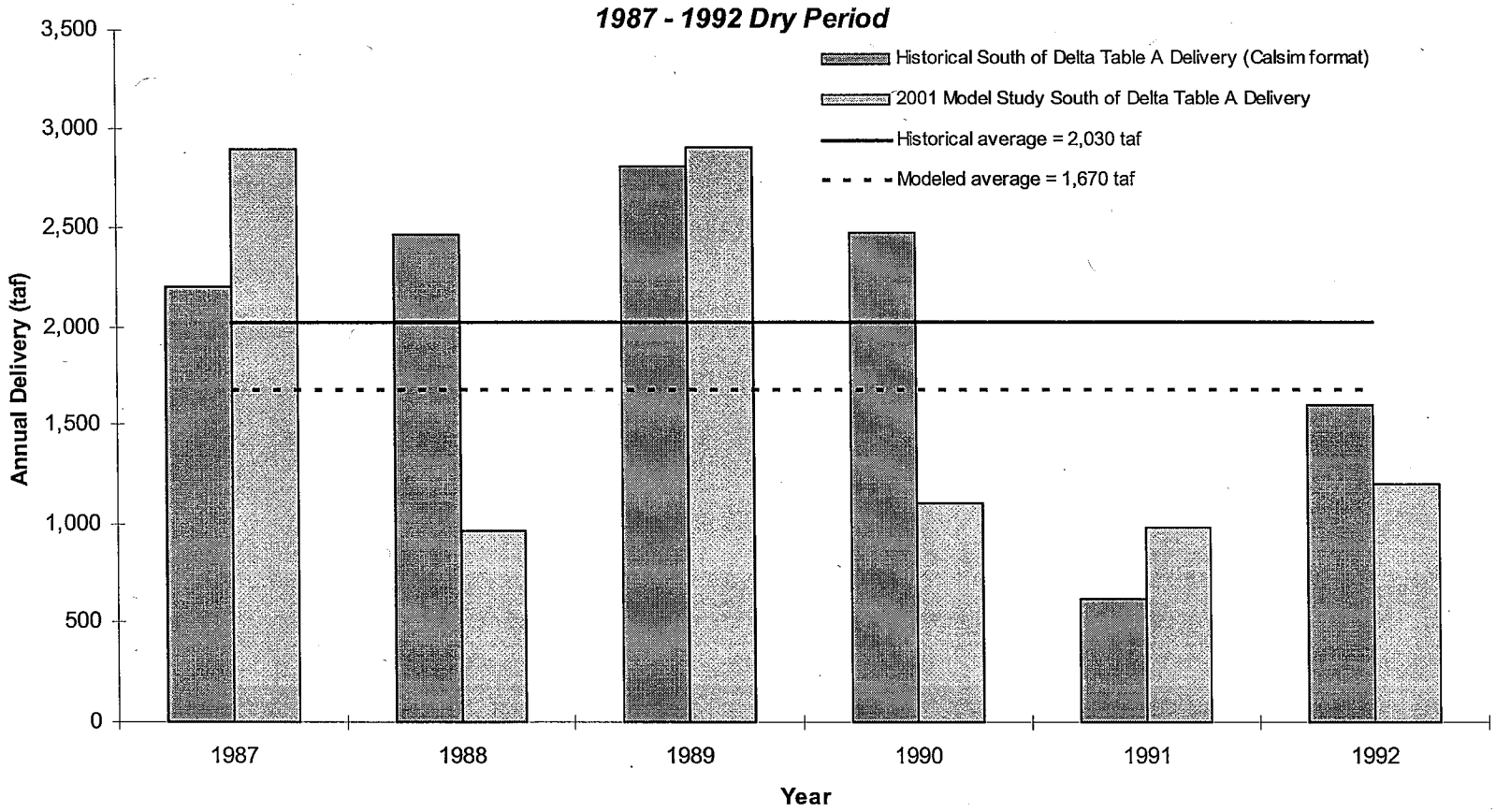


**Figure 3**
**Historical SWP Table A Delivery versus 2001 D-1485 Model Study SWP Table A Delivery**
***1987 - 1992 Dry Period***

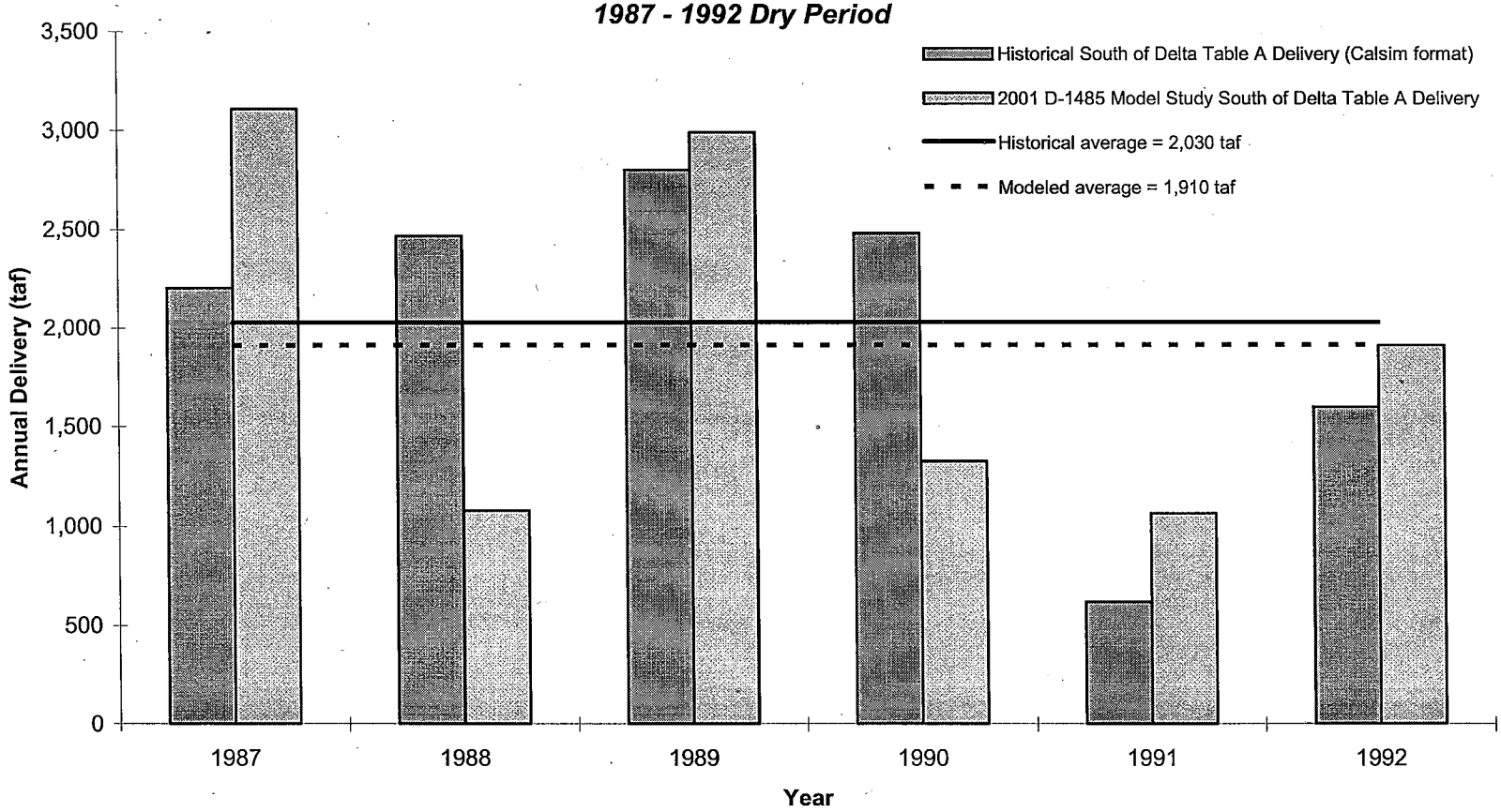
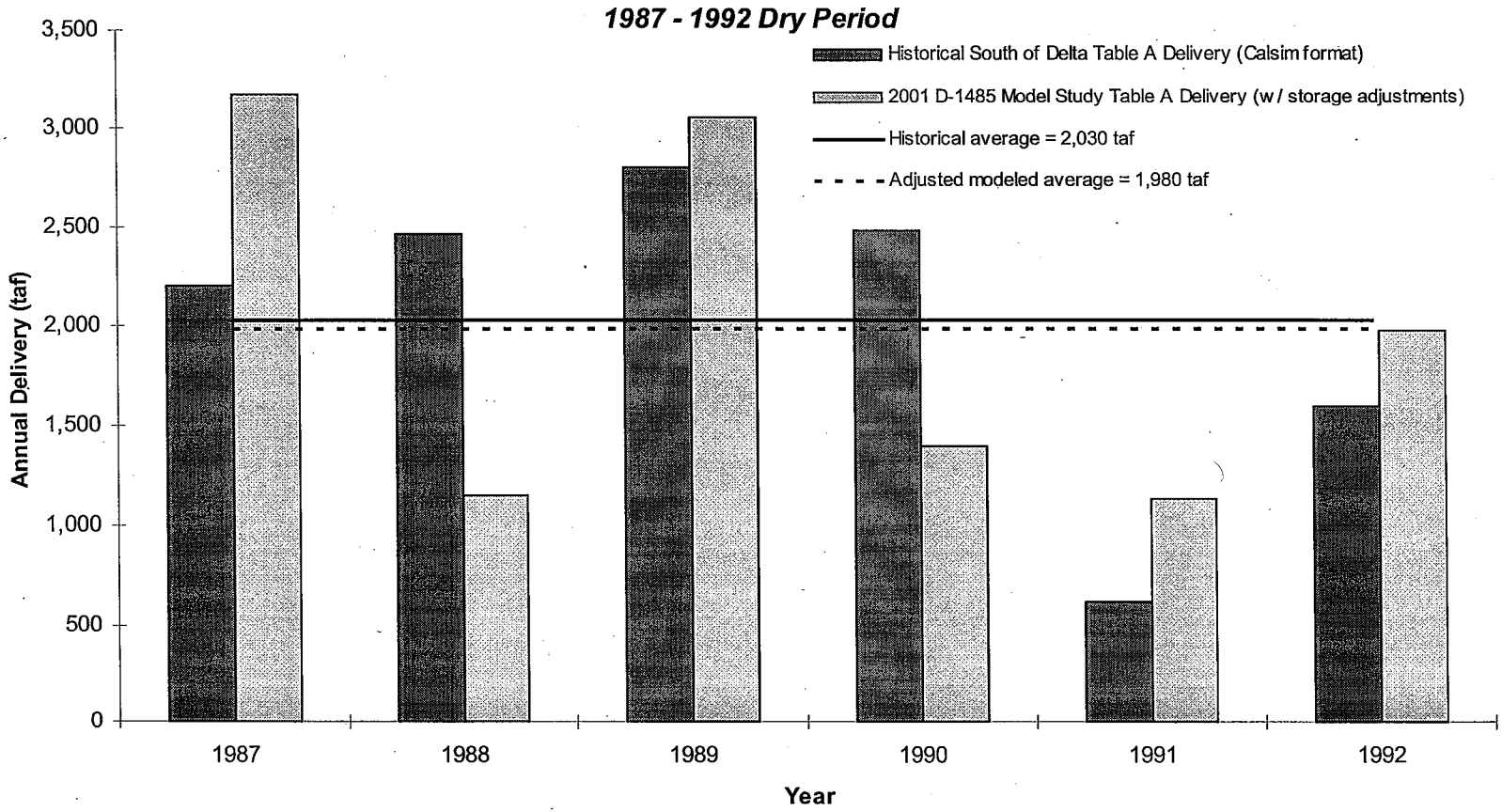


**Figure 4**
**Historical SWP Table A Delivery v. Adjusted 2001 D-1485 Model Study SWP Table A Delivery**
***1987 - 1992 Dry Period***



## Upstream Depletion

Estimates of demands and water use are part of the hydrology development for CALSIM II. Areas upstream of the Sacramento-San Joaquin Delta are divided into hydrologic basins or units known as Depletion Study Areas. These depletion areas are categorized as valley floor areas and rim basin areas. Because valley floor areas are more complex, have large demands, and need to be integrated with the operation of the CVP/SWP, they are represented in CALSIM II in much greater detail than rim basins. Flows from rim basins are determined prior to simulating CALSIM II and are input as a fixed time series. The attached map shows the delineation of the DSA boundaries.

The land use acreage used to develop water demands for each DSA is based on the desired Level of Development. Fixed levels of land use are used to determine water demands for the existing (normalized year 1995) and future (year 2020) LOD. The table below contains land use assumptions for each DSA in the Sacramento Basin. Levels of development between 1995 and 2020 are estimated by linear interpolation.

Sacramento Basin, Valley Floor Land Use (acres)

| | 1995 | | 2020 | | Difference | |
|---|---|---|---|---|---|---|
| DSA | Urban | Agriculture | Urban | Agriculture | Urban | Agriculture |
| 58 | 67,400 | 37,400 | 110,000 | 33,700 | 42,600 | -3,700 |
| 10 | 21,800 | 188,000 | 33,300 | 199,600 | 11,500 | 11,600 |
| 12 | 7,900 | 370,100 | 12,800 | 386,000 | 4,900 | 15,900 |
| 15 | 3,400 | 279,200 | 4,800 | 279,800 | 1,400 | 600 |
| 69 | 49,900 | 392,400 | 81,000 | 384,800 | 31,100 | -7,600 |
| 65 | 38,100 | 265,400 | 61,100 | 255,600 | 23,000 | -9,800 |
| 70 | 180,500 | 126,800 | 284,600 | 108,100 | 104,100 | -18,700 |
| 54 | 17,900 | 297,700 | 28,800 | 291,300 | 10,900 | -6,400 |
| 55 | 24,900 | 135,300 | 35,700 | 126,400 | 10,800 | -8,900 |
| Total | 411,800 | 2,092,300 | 652,100 | 2,065,300 | 240,300 | -27,000 |

Source: DWR, Bay-Delta Office, CU model input for use in CALSIM II, based on Bulletin 160-98 data.

Water consumption for different land use categories is calculated using DWR's Consumptive Use model. The CU model simulates monthly soil moisture conditions over the 73-year period of simulation for 12 different agricultural crop categories, urban irrigated landscape and native vegetation for each DSA. Based on minimum soil moisture requirements the CU model calculates the Consumptive Use of Applied Water for the irrigated land use categories. Municipal and industrial demands are not fully addressed in the CU model. A large portion of M&I demands are non-consumptive and, therefore, not considered by the CU model. M&I diversions can have a large influence on reservoir operations and have, therefore, been included in CALSIM II for the American and Lower Sacramento rivers. M&I water diversion requirements are determined based on recent historic diversions for existing LOD and contract amounts for future LOD.

The CU model uses a very simple approach to estimate outdoor urban water demands. The urban land use classification combines residential, commercial and industrial sectors. The total urban acreage is subsequently proportioned between "lawns," "vacant lots" and "impervious surfaces." To calculate the consumptive use of these three land types, the following assumptions are made:

- Consumptive use of lawns is identical to irrigated pasture;
- Consumptive use of vacant lots is identical to native vegetation; and
- All precipitation on impervious surface results in runoff, i.e., zero consumptive use.

The CU model assumes 10-15 percent of CUAW is lost to the system as non-recoverable losses. The CU model is also used to adjust the historical rainfall runoff due to any land use change. The table below contains average annual irrigation demands by crop and DSA as calculated by the CU model. The total average annual depletion (CUAW and non-recoverable losses) for the Sacramento Valley floor at 2001 LOD is 4,749 taf/yr compared to 4,875 taf/yr at 2020 LOD.

Consumptive Use of Applied Water (ac-ft/ac)

| DSA | Alfalfa | Citrus | Cotton | Field | Grain | Truck | Orchard | Pasture | Rice | Sugar Beets | Toma-toes | Vines | Urban |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 2.6 | 1.6 | | 1.4 | 0.2 | 1.3 | 2.2 | 3.0 | 3.5 | 2.0 | 2.1 | 1.8 | 0.8 |
| 12 | 2.8 | | 2.0 | 1.5 | 0.3 | 1.4 | 2.2 | 3.1 | 3.6 | 2.1 | 2.0 | 1.9 | 0.8 |
| 15 | 2.8 | | 2.0 | 1.5 | 0.3 | 1.3 | 2.2 | 3.2 | 3.6 | 2.1 | 2.0 | | 0.8 |
| 58 | 2.3 | 1.4 | | 1.3 | 0.1 | 1.2 | 2.1 | 2.7 | | | | 1.7 | 0.7 |
| 65 | 2.7 | | | 1.5 | 0.2 | 1.4 | 2.2 | 3.1 | 3.6 | 2.1 | 2.0 | 1.7 | 0.8 |
| 69 | 2.6 | | 2.0 | 1.4 | 0.2 | 1.3 | 2.2 | 3.0 | 3.5 | 2.0 | 1.9 | | 0.7 |
| 70 | 2.7 | | | 1.5 | 0.2 | 1.3 | 2.3 | 3.0 | 3.5 | 2.1 | 1.9 | 1.9 | 0.8 |
| 55 lowland | 1.9 | | | 1.3 | 0.0 | 0.9 | 1.3 | 2.6 | 3.4 | 1.5 | 1.2 | 1.2 | 0.6 |
| 55 upland | 2.9 | | | 1.6 | 0.3 | 1.7 | 2.4 | 3.0 | 3.6 | 2.3 | 1.9 | 1.9 | 0.8 |

Notes: Blank values indicate that the crop is not grown in the region.
Reported urban CUAW is based on an assumed irrigated landscape area of 25%

The current figures in the SWP Delivery Reliability Report are based on Bulletin 160-98 land use estimates. The next revision of the report, planned in approximately two years, will be based on revised estimates in the California Water Plan Update 2003.

The calculation of irrigation demands for paddy rice differs from other crops. During the growing season rice fields are flooded to control weed growth. In the CU model water applied for flooding in April and subsequent months is treated as a consumptive use. The fields are assumed to be flooded to a depth of nine inches. The water recovered through draining the fields in September (1.5 to 2.0 inches) is added to the local water supply as an accretion. The quantity and timing of irrigation demands

represent average planting and harvesting conditions in each DSA. Return flows from rice drainage are added to the time series of accretions for each basin. Return flows average approximately 70 taf/yr from a total of 485,000 acres of paddy rice at the 2001 LOD. Over the last few decades there have been substantial changes in the quantities of water diverted for rice production. Applied water demands have dropped as irrigation efficiencies have increased and farmers have switched to varieties with shorter growing periods. More recently fall flooding of rice fields for decomposition of rice straw has been adopted as an alternative to burning. Irrigation demands for rice are currently being reviewed and it is likely that model demands will be adjusted for the CALSIM II runs required to support the California Water Plan Update 2003.

## CALSIM II Evaluation

DWR's Bay-Delta Office is currently undertaking a "historical project operations study" to investigate the accuracy of the model's water supply estimates. The purpose of the historical project operations study is to compare CALSIM II results with historical operations and investigate the source of any differences in historical and simulated performance. The historical project operations studies is part of a larger CALSIM II evaluation process. Other components of this evaluation will include a survey of stakeholders; a model peer review by leading academics and practitioners; and a sensitivity analysis on model inputs and parameters. Initial results from the historical project operations study are expected to be available by March 2003.

The historical project operations study, conducted by DWR, will compare CALSIM II model results to recent historical operations for water years 1975 to 1998. This 24-year period includes both the 1976-77 and 1987-92 droughts. It also includes water year 1998 that is one of two years for which detailed analysis of historical water supply and demand is being conducted as part of the California Water Plan Update 2003 (Bulletin 160-03).

For the historical project operations study, input to the current CALSIM II model will be changed to reflect historical conditions. The inflow hydrology will be revised to reflect historical rather than current or projected level of development. Demand will be calculated for the historical land use, based on DWR's land surveys and county commissioners' reports, rather than a fixed level of development. Project contracts and entitlements will be changed to their historical level. Lastly operation logic will be changed to reflect the changing regulatory base line such as the release of the State Water Resources Control Board 1995 Water Quality Control Plan and State and federal biological opinions for Delta smelt and Chinook salmon.

The study will be limited in geographical scope to a dynamic operation of the Sacramento Valley, the Delta, and CVP-SWP facilities south of the Delta. Delta inflows from the San Joaquin Valley and the East Side Streams will be fixed at their historical level. In dry years when the system is system is supply limited, the SWP target demands will be set equal to the historical requests. In wet years when the system is demand driven, target demands will be set equal to historical deliveries. Similarly for the CVP, historical requests or annual contract amounts will be an upper bound on CVP deliveries.

Modeling of the CVP-SWP system and areas contributory to the Sacramento-San Joaquin Delta requires considerable input data. The majority of the data relates to either system inflows or demand data for the 73-year period of simulation. As described in page 7 of the report, DWR has committed to undertake a sensitivity analysis on SWP water delivery reliability. This analysis would examine the effects of certain assumptions, parameters and input data on model results. The aim of the sensitivity analysis is to identify the input data that most strongly affect model results so that future

work within the Department can be focused on refining estimates of these key determinants.

The current representation of groundwater in CALSIM II is only a first step towards developing a fully integrated groundwater surface water model. The Department is currently developing the Central Valley Groundwater Surface water Model with the eventual aim of linking this model to CALSIM II to study impacts of surface water operations, groundwater pumping and land use change on groundwater elevations. The current groundwater model component of CALSIM II affects surface water operations through the calculation of the stream-groundwater interaction. There is considerable uncertainty about the magnitude of this interaction. In areas with high groundwater levels, groundwater inflow to streams is a function of groundwater head. In areas of low groundwater elevation where stream seepage flows to the groundwater, there is an assumed hydraulic disconnect between the stream and the aquifer so that seepage is independent of groundwater elevation. It is acknowledged that groundwater elevations are not accurately modeled in CALSIM II. As calculated by CALSIM II, groundwater inflows to the stream system in the upper Sacramento Valley average 255 taf/yr. Stream losses to groundwater in the lower Sacramento Valley average 40 taf/yr. This compares with an average annual Sacramento River inflow to the Delta (at Freeport) of approximately 16 maf/yr.

In any discussion on model "calibration" it is important to remember that CALSIM II is a mass-balance accounting model and *not* a distributed hydrologic model that simulates a physical process. It is also important to understand that the hydrology development is based on historical gage data. Valley floor accretions and depletions are calculated as closure terms in a hydrologic mass balance calculated for each Depletion Study Area. The accretions represent local ungaged runoff into the stream system and are calculated based on gage data for stream inflows and outflows across the hydrologic boundary and estimates of urban and agricultural consumptive use of applied water within the region. The accretions and depletions also contain all the errors in the mass balance stemming from poor gage data or incorrect estimates of groundwater extraction or agricultural and urban water use. True calibration techniques can only be applied to a few components of the CALSIM II model, such as the Artificial Neural Network used for determining flow-salinity relationships in the Delta and the multi cell groundwater model.

**Responses to Other Comments from Dennis O'Connor, Assistant Director, California Research Bureau**

**Comment:** Except for the year 2000, historical deliveries are always less than the median modeled delivery of 3.3 maf.

**Response:** The 73-year median modeled delivery of 3.30 maf is based on year 2001 level of development including 2001 SWP demand conditions. SWP contractor's requests for water have increased in recent years and reached 4.1 maf in 2001 and initial requests for 2003 are also 4.1 maf. The highest SWP Contractor's request prior to 2001 was 3.6 maf which occurred in the years 1992 and 2000. This request is slightly lower than the 73-year median model demand of 3.74 maf. Since the 2001 model study includes SWP water demand which is significantly higher than historical levels prior to 2001, modeled water deliveries often exceed historical deliveries.

**Comment:** SWP contractor's Table A requests have been higher than the median modeled delivery on 9 occasions.

**Response:** Our records show that SWP contractor's Table A requests have exceeded the median modeled delivery of 3.3 maf in six years as shown in the following table. The years with requests above 3.3 maf are 1991, 1992, and 2000 through 2003.

| Year | SWP Contractor's Table A Request (maf) |
|---|---|
| 1986 | 2.4 |
| 1987 | 2.7 |
| 1988 | 2.6 |
| 1989 | 3.0 |
| 1990 | 3.1 |
| 1991 | 3.5 |
| 1992 | 3.6 |
| 1993 | 2.7 |
| 1994 | 2.7 |
| 1995 | 3.1 |
| 1996 | 2.7 |
| 1997 | 3.0 |
| 1998 | 3.2 |
| 1999 | 3.2 |
| 2000 | 3.6 |
| 2001 | 4.1 |
| 2002 | 3.9 |
| 2003 | 4.1 |

**Comment:** SWP has delivered 95 percent or more of contractor's requests only once in the last 12 years.

**Response:** For the period 1989-2002, the SWP allocated 100 percent of the contractor's requests in 1989, 1993 and 1996-1999. Project water delivery was 95 percent of the requested amount in 1989 and 93 percent of the requested amount in 1996. Project water deliveries in the years 1993 and 1997-1999 ranged from 55 to 85 percent of the initial requests due to substantial improvement in local water supplies after the request was submitted.

**Comment:** The minimum model demand of 3.0 maf is well above the 1.7 maf ultimately demanded by SWP contractor's in 1998. CALSIM does not consider that contractors might reduce their demand below 3.0 maf.

**Response:** Many factors must be considered when estimating the appropriate level of SWP model demand for each year including local rainfall in the water use areas. Currently, SWP model demands have only been determined through 1994. The wet year of 1998 had above normal winter precipitation as well as unusually high rainfall in May. Sacramento had 3.04 inches of rain in May 1998 (661 percent of normal) while the Los Angeles Civic Center had 3.10 inches (1,940 percent of normal). To the extent possible, actual 1998 conditions will be taken into account when modeling 1998.

**Comment:** The median model delivery in below-normal years is higher than the median model delivery in above-normal years.

**Response:** The median model delivery in below-normal years is 46 taf greater than the median model delivery in above-normal years. This occurs because the average model demand in below-normal years is 164 taf higher than the average model demand in above-normal years as shown in the attached Figure 1. In below-normal years, the resources are often still available to supply this higher demand.

**Comment:** The adjusted historical SWP Table A dry-year delivery of 1.4 maf in 2001 is less than all modeled Table A deliveries in years classified as dry.

**Response:** The adjusted delivery of 1.4 maf in 2001 does not include 160 taf of water allocated in 2001 and carried over and delivered in 2002. This carryover should be added to the 1.4 maf delivery to make it comparable to modeled deliveries. With this adjustment, the value for 2001 is 1.56 maf, which is slightly higher than the lower bound of the modeled delivery in dry years.

**Comment:** The adjusted historical SWP Table A wet-year deliveries of 1.7 maf in 1998 and 3.0 maf in 1999 are less than all modeled Table A deliveries in years classified as wet.

**Response:** Modeled deliveries are similar to 1999 in three years classified as wet. The wet year of 1998 had above normal winter precipitation as well as unusually high rainfall in May. To the extent possible, actual 1998 conditions will be taken into account when modeling 1998.

**Comment:** Why does 2021 delivery exceed 2001 delivery in the exceedance range of 80 to 85 percent in Figure 1 of the draft report?

**Response:** Increased urbanization from 2001 to the 2021 projected level of development results in greater precipitation-runoff. Increased 2021 demands will result in greater groundwater pumping. These two factors result in higher delivery in 2021 compared to 2001 in the 80 to 85 percent range of Figure 1 of the draft report. The dry years with higher delivery in 2021 compared to 2001 are 1932, 1933 and 1960. The modeled depletion, precipitation-runoff gain and groundwater pumping for the 2001 and 2021 studies for the 1922-1994 study period and each of these years are shown in Tables 1, 2, 3 and 4, respectively.

**Comment:** SWP delta exports cannot be evaluated without also looking at CVP delta exports.

**Response:** DWR and the Bureau of Reclamation, in coordination with public agencies, have spent over two years developing CALSIM II. For years, the Bureau and DWR used different computer models to conduct planning analyses. The Bureau and DWR now agree CALSIM II sufficiently represents the operation of the CVP and the SWP and is the best model of its type for analyzing proposed projects. The studies used in the report are referred to as Benchmark Studies (May 17, 2002) and have been reviewed and accepted by the Bureau and DWR. Summary reports of the results of these studies, including the values for CVP exports, are available on the Internet at http://modeling.water.ca.gov/hydro/studies/SWPReliability/index.html.

**Comment:** CALSIM II assumes water delivered any time of the year is useful to all contractors.

**Response:** The monthly model demands are based on historical data and information received from SWP contractors. Under some contracts, project water is delivered in a monthly pattern that assumes the individual contractor will provide local storage facilities when using SWP water to meet local water demand.

**Comment:** The historical weather pattern is no longer a reliable indicator of the future.

**Response:** The impact of global warming is being evaluated as part of the *2003 California Water Plan Update* (Bulletin 160). The incorporation of the potential effects of global warming in estimates of the delivery ability of the SWP is expected to be a topic addressed in the peer review and other public discussions regarding CALSIM II.

**Comment:** The modeling simulation does not include the years 1995-2001.

**Response:** We are currently updating the CALSIM II database to include the years 1995-1998. The quality-control process for some of the data needed for CALSIM II is a slow one. Updating CALSIM II with post-1998 data will be done at a later date.

**Table 1**
**Average Precipitation-Runoff Gain, Depletion and Groundwater Pumping for Sacramento Valley Depletion Study Areas**
(1922-1994 average in taf/year)

| | 2001 Study | 2021 Study | 2021 Study minus 2001 Study |
|---|---|---|---|
| Precipitation-runoff gain | 4,683 | 4,828 | 145 |
| Depletion | 4,749 | 4,875 | 126 |
| Net groundwater pumping | 1,217 | 1,278 | 61 |
| Gain - depletion + pumping | 1,151 | 1,231 | 80 |

**Table 2**
**1932 Precipitation-Runoff Gain, Depletion and Groundwater Pumping for Sacramento Valley Depletion Study Areas**
(taf/year)

| | 2001 Study | 2021 Study | 2021 Study minus 2001 Study |
|---|---|---|---|
| Precipitation-runoff gain | 1,958 | 2,041 | 83 |
| Depletion | 5,026 | 5,144 | 118 |
| Net groundwater pumping | 1,995 | 2,085 | 90 |
| Gain - depletion + pumping | -1,073 | -1,018 | 55 |

**Table 3**
**1933 Precipitation-Runoff Gain, Depletion and Groundwater Pumping for Sacramento Valley Depletion Study Areas**
(taf/year)

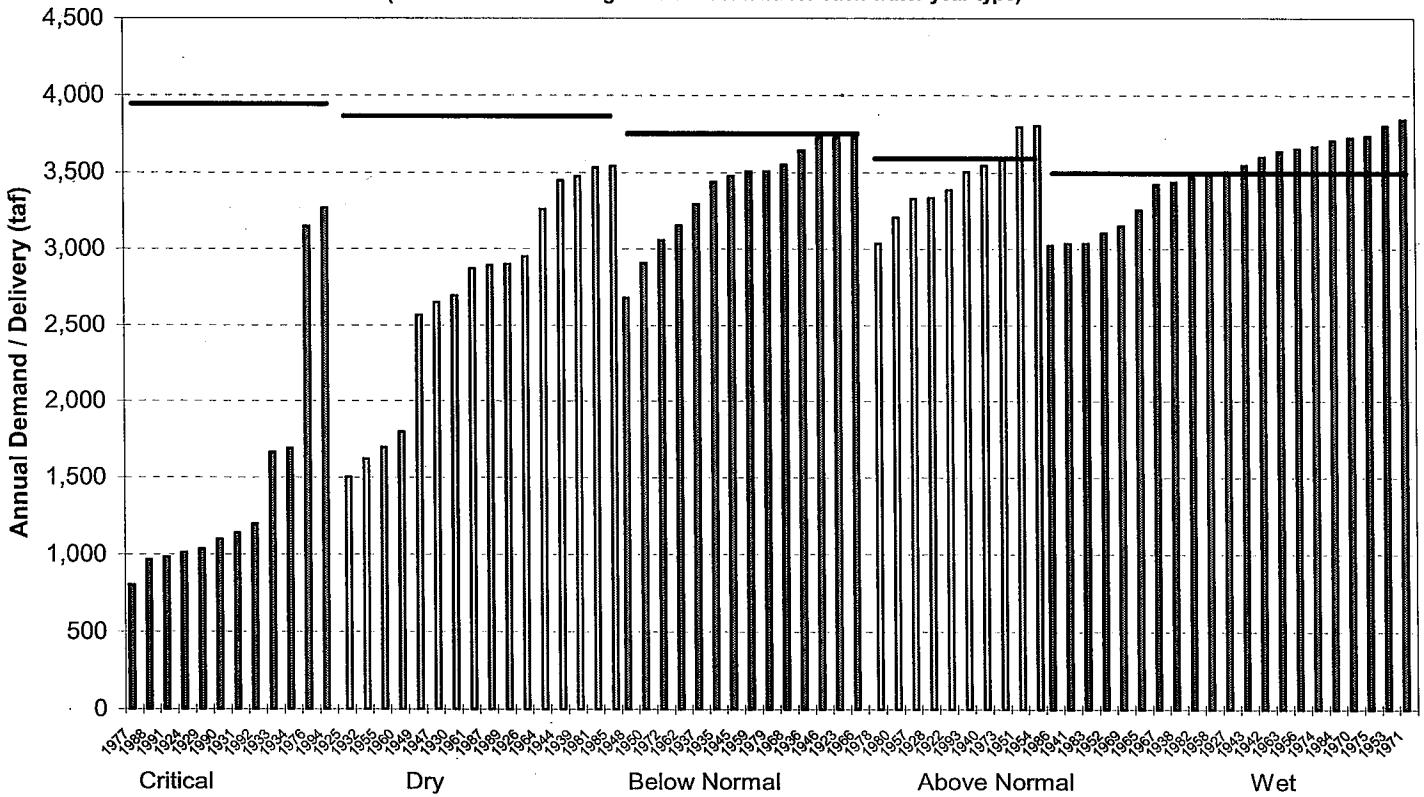
| | 2001 Study | 2021 Study | 2021 Study minus 2001 Study |
|---|---|---|---|
| Precipitation-runoff gain | 1,726 | 1,871 | 145 |
| Depletion | 5,190 | 5,295 | 105 |
| Net groundwater pumping | -1,966 | 2,055 | 89 |
| Gain - depletion + pumping | -1,498 | -1,369 | 129 |

**Table 4**
**1960 Precipitation-Runoff Gain, Depletion and Groundwater Pumping for Sacramento Valley Depletion Study Areas**
(taf/year)

| | 2001 Study | 2021 Study | 2021 Study minus 2001 Study |
|---|---|---|---|
| Precipitation-runoff gain | 3,060 | 3,221 | 161 |
| Depletion | 4,788 | 4,925 | 137 |
| Net groundwater pumping | 1,263 | 1,355 | 111 |
| Gain - depletion + pumping | -465 | -349 | 135 |

Note: Precipitation-runoff gain is the stream flow accretion due to local ungaged streams that are not modeled explicitly in CALSIM II.
Net groundwater pumping is the net groundwater extraction calculated as pumping less recharge from deep percolation.

**Figure 1**
**2001 Model Study Table A Delivery Sorted By Water Year Type**
**(Bold lines show average Table A demand for each water year type)**



Attachment 26

S.4

BILL LOCKYER
Attorney General

State of California
DEPARTMENT OF JUSTICE

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REC
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VISION

October 23, 2006

County of San Bernardino
Land Use Services Department, Advance Planning Division
385 North Arrowhead Avenue, First Floor
San Bernardino, CA 92415-0182
Attn: James Squire

RE: DEIR on San Bernardino County General Plan Revision

**TRANSMITTED BY FACSIMILE AND U.S. MAIL**

Dear Mr. Squire:

The Attorney General of the State of California submits the following comments regarding the San Bernardino County General Plan Revision Draft Environmental Impact Report ("DEIR"). The Attorney General provides these comments pursuant to his independent power and duty to protect the natural resources of the State from pollution, impairment, or destruction in furtherance of the public interest. (*See* Cal. Const., art. V, § 13; Cal. Gov. Code, §§ 12511, 12600-12; *D'Amico v. Board of Medical Examiners*, 11 Cal.3d 1, 14-15 (1974).) These comments are made on behalf of the Attorney General and not on behalf of any other California agency or office. While these comments focus on some of the air quality and global warming issues raised by the DEIR, they are not an exhaustive discussion of all issues.

## I. Introduction

The Plan is described as being San Bernardino County's "blueprint" for land use and development through 2030. The Plan projects population growth of about 25% by 2030 (DEIR, p. I-1), in an area that already accounts for about ten percent of the total daily trips made in the entire region. (Circulation and Infrastructure Background Report, p. 2-34.) However, the environmental analysis in the DEIR fails to adequately analyze air quality impacts and contains no analysis at all of the impact of the Plan on climate change; both omissions violate the California Environmental Quality Act ("CEQA"), Pub. Resources Code §§ 21000, et seq. As the DEIR acknowledges, San Bernardino County already has a critical air pollution problem, with state air quality standards for ozone and fine particulate matter having been exceeded on 91 days and 82 days, respectively, in 2002. (Conservation Background Report, p. 6-94.) Even though the County receives transported air pollution from the rest of the South Coast Air Basin, and from 1

the San Joaquin Valley (Conservation and Background Report, p. 6-92), the County itself contributes very significantly to this problem, with a very large rate of trips per day per resident, and an abysmally low rate of transit use. (Circulation and Infrastructure Background Report, p. 2-34.) The large amounts of land available for development present the probability that this problem will grow more severe during the lifetime of the General Plan revision. The environmental and public health concerns raised by the projected increases in vehicular travel under the proposed plan deserve, and CEQA requires, serious and thorough environmental analysis. 1

We note that the Legislature has recently enacted, and Governor Schwartzenegger has signed, AB 32, the landmark law to control and reduce the emission of global warming gases in California. We are extremely concerned that this legislation was not addressed in any way by either the draft General Plan revision or the DEIR. AB 32 requires both reporting of greenhouse gas emissions and their reduction on a brisk time schedule, including a reduction of carbon dioxide (CO2) emissions to 1990 levels by 2020. Local governments will be called upon to help carry out the legislation's provisions, and its General Plan revision is the appropriate place for the County to identify both CO2 and other greenhouse gas sources, as well as actions for mitigation of the increases in emissions in greenhouse gases resulting from actions set forth in the General Plan revision. Because global warming is perhaps the most serious environmental threat currently facing California, the DEIR should and must address the issue, provide full environmental disclosure of the effects on greenhouse gas emissions that the General Plan revision will cause, and adopt serious and real mitigation measures for those effects and emissions. 2

## II. The General Plan Should Address and Include Measures to Reduce Greenhouse Gas Emissions, and the DEIR Should Discuss The Plan's Impact On Climate Change.

The General Plan revision projects that San Bernardino County's population will grow overall by about 25% by 2030, and the background documents indicate that the areas covered by Community Plans will experience about a 50% increase in population during that time. (DEIR App.C, p. 5.) The Plan relies upon on vehicular travel and improvements to freeways, roads and streets to deal with the travel needs of this expanded population, and acknowledges that the land uses permitted in the General Plan will increase traffic and may result in a substantial increase in vehicle trips unless mitigated. (DEIR, p. IV-169.) However, the DEIR never analyzes one of the most important environmental impacts of vehicle emissions -- greenhouse gases and resulting climate change. 3

Climate change results from the accumulation in the atmosphere of "greenhouse gases" produced by the burning of fossil fuels for energy. Because greenhouse gases (primarily, carbon

dioxide("$CO_2$"), methane and nitrous oxide) persist and mix in the atmosphere, emissions anywhere in the world impact the climate everywhere. The impacts on climate change from greenhouse gas emissions have been extensively studied and documented. (*See* Oreskes, Naomi, *The Scientific Consensus on Climate Change*, 306 Science 1686 (Dec. 3, 2004) [review of 928 peer- reviewed scientific papers concerning climate change published between 1993 and 2003, noting the scientific consensus on the reality of anthropogenic climate change]; J. Hansen, *et al.*, *Earth's Energy Imbalance: Confirmation and Implications*, Sciencexpress (April 28, 2004) (available at http://pubs.giss.nasa.gov/abstracts/2005/HansenNazarenkoR.html ) [NASA and Department of Energy scientists state that emission of $CO_2$ and other heat-trapping gases have warmed the oceans and are leading to energy imbalance that is causing, and will continue to cause, significant warming, increasing the urgency of reducing $CO_2$ emissions].) 3

In AB 32, the Legislature recognized California's particular vulnerability to the effects of global warming, making legislative findings that global warming will "have detrimental effects on some California's largest industries, including agriculture, wine, tourism, skiing, recreational and commercial fishing, and forestry." (Health and Saf. Code section 38501, subd. (b).) San Bernardino County will feel the effects of climate change in many of these areas, particularly given the importance to the County of its Mountain area's economic dependence on tourism, skiing, recreational fishing, and recreational second homes. (Economic Development Background Report, App. A, pp. 57-59.)) The Legislature also found that global warming will "increase the strain on electricity supplies necessary to meet the demand for summer air-conditioning in the hottest parts of the State." (Health and Saf. Code, section 38501, subd. (b).) Since San Bernardino, and especially its Desert areas, are among the parts of the State that do experience hot weather, the County will suffer acutely from any electricity shortages caused by the strains of global warming, as it will also feel the economic and public health damages from decreased snowpack and increased air pollution that a changed climate will bring -- indeed, is already bringing. 4

To prevent these harms, AB 32 mandates that emissions of greenhouse gases to 1990 levels must be required by whatever regulatory scheme the Air Resources Board, the agency charged with carrying out the statute, ultimately adopts. (Health and Saf. Code section 38530.) Governments are not exempt from AB 32. The County, its cities, and the businesses within its borders will all have to comply with the regulations and plans that will be adopted to achieve the reduction of greenhouse gas emissions mandated by this legislation.

Nor is AB 32 the first state-wide recognition of the ravages global warming may wreak on California. In Executive Order S-3-05, issued on June 1, 2005, Governor Schwarzenegger recognized the significance of the impacts of climate change on the State of California, noting that "California is particularly vulnerable to the impacts of climate change." And, even before 5

AB 32, the Legislature recognized the severe impacts that come from climate change, as well as a "projected doubling of catastrophic wildfires due to faster and more intense burning associated with drying vegetation." (Stats. 2002, ch, 200, Section 1, subd. (c)(4), enacting Health & Saf. Code § 43018.5). In the particular realm of vehicular travel and emissions from cars and truck, the California legislature went on to recognize that "passenger vehicles and light-duty trucks are responsible for *40 percent of the total greenhouse gas pollution in the state*." (*Ibid.*, subd. (e)(emphasis added).) Our knowledge of the existence and severity of the problem of greenhouse gas emissions and global warming is not new, but was apparent and recognized before the draft General Plan revision was issued by the County. 5

Despite the existence of Executive Order S-3-05 and the pendency of AB 32 during the time that the General Plan revision was being prepared, the County does not even mention the issue in its General Plan revision, although that revision is meant to cover the next quarter century. Nor does the DEIR analyze, on even the most superficial level, emissions of carbon dioxide, climate change or global warming, despite the obvious connection between such emissions and land use planning, transportation planning, or even air quality. No mitigation for emissions of greenhouse gases is proposed or adopted. 6

Under CEQA, an environmental impact report must identify and focus on the "significant environmental effects" of a proposed project. (Public Res. Code section 21100(b)(1); Cal. Code Regs., tit. 14, §§ 15126(a), 15126.2(a), 15143.) "'Significant effect on the environment' means a substantial, or potentially substantial, adverse change in the environment." (Public Res. Code section 21068). CEQA also provides that the CEQA guidelines "shall" specify certain criteria that *require* a finding that a project may have a significant effect on the environment:

> "(1) A proposed project has the potential to degrade the quality of the environment, curtail the range of the environment, or to achieve short-term, to the disadvantage of long-term, environmental goals.
>
> (2) The possible effects of a project are individually limited but cumulatively considerable. As used in this paragraph, "cumulatively considerable" means that the incremental effects of an individual project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects.
>
> (3) The environmental effects of a project will cause substantial adverse effects on human beings, either directly or indirectly."
> (Public Res. Code section 21083(b).)

The CEQA Guidelines, Cal. Code of Regs., tit. 14, section 15064, subdivision (h)(3), provide that an agency may conclude that an environmental effect is not cumulatively considerable if it complies with an existing plan to meet environmental standards, such as a state implementation plan or a basin plan. The DEIR itself includes as one of its significance criteria for air quality the potential of the project to "[v]iolate any air quality standard or contribute substantially to an existing or projected air quality violation."[1] Here, the plans to reduce global warming are still to be formulated, but after the passage of AB 32, we know, as stated above, that a reduction of emissions of greenhouse gases to 1990 levels will be required by whatever regulatory scheme is ultimately adopted. (Health and Saf. Code section 38550.) This provision of the Guidelines does not exempt the County from doing a CEQA analysis of this issue. 7

In other words, if the General Plan revision could allow emissions of greenhouse gases to significantly affect the environment, directly, indirectly, or cumulative, then the EIR on the revision must analyze the issue, disclose all that can feasibly be found out and disclosed, and adopt all feasible mitigation measures. The DEIR reports that currently, San Bernardino generates about 5.2 million person trips per day (about 10.35 trips per household per day), and that over 84 % of the work trips are made by car. (Circulation and Infrastructure Background Report, p. 2-34.) Given that the DEIR projects an increase in population of about 436,500 people by 2030, vehicular miles traveled by the year 2030 can be expected to grow substantially. Considering that about 40% of greenhouse gas emissions come from motor vehicles, the revision clearly "has the potential to degrade the environment" as to greenhouse gases and global warming. (*See ibid.*, subd. (b)(1).) Moreover, the cumulative effects of this project on greenhouse gas emissions, when taken in consideration with the impacts statewide of increased population and vehicular travel over the next quarter century, are undeniable. (*See ibid.*, subd. (b)(2).) When considering the impacts of climate change on California, it is impossible to ignore that the impacts of this project will have either direct or indirect effects on human beings. (*See ibid.*, subd. (b)(3).) Given the scope of the General Plan revision, the projected increase in population and vehicle travel it projects, and the fact that it projects a steady and large increase in population, there is no question that the impacts of the General Plan revision on greenhouse gas emissions and climate change may, and likely will, have significant cumulative environmental impacts for California. These impacts should have been considered, analyzed, and mitigated in the DEIR. 8

Such an analysis is possible; the data are obtainable. Carbon dioxide emissions from cars can be quantified. In fact, under AB 32, an inventory of greenhouse gas emissions *must* be done in time to allow the 1990 level of such emissions to be determined by the statutory deadline of

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1. DEIR, p. IV-27.

January 1, 2008. (Health and Saf. Code sections 38530, 35850.)[2] This is such a short time that such an emissions inventory should begin immediately. However, current information on the greenhouse gas emissions of cars, trucks and buses could be used to compile an estimated inventory. Once such an estimated inventory is completed, the projections of increased driving that are in the General Plan revision could be used to estimate future growth in greenhouse gas emissions associated with the revision. The California Air Resources Board has information that could be applied to the projected increase in driving. The impacts could be assessed as to their cumulative impact on climate change, assuming (as is highly probable based on the population growth in the General Plan revision and the widely distributed nature of that growth) that there would be a considerable impact from the increase in $CO_2$ resulting from the increased driving. (*See* Cal. Code Regs., tit. 14, § 15130(a) ["an EIR shall discuss cumulative impacts of a project when the project's incremental effect is cumulatively considerable."] *See also* Cal. Code Regs., tit. 14, § 15065(a)(3) ["'Cumulatively considerable' means that the incremental effects of an individual project are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probably future projects."].) 8

Moreover, and most importantly, the General Plan revision could and should include mitigation for these impacts. The Governor has recognized, "mitigation efforts will be necessary to reduce greenhouse gas emissions and adaptation efforts will be necessary to prepare Californians for the consequences of global warming." (Executive Order S-3-05, June 1, 2005.) The County can both require mitigation measures from businesses and entities within its jurisdiction, through alternations to its building codes or permit requirements; e.g., it might require solar heating capabilities for all new development, or require that carbon sequestration credits be purchased for development of a certain size. The County could take direct action to offset its own carbon emissions, or those of its residents, by providing for increased public transportation service, increased support of alternative fuels and technologies, installation of electric vehicle charging stations, and other affirmative steps to reduce the transportation impacts of $CO_2$. These are real, achievable and available mitigation measures that could be considered when San Bernardino County recognizes its obligations to analyze greenhouse gas emissions and their impact on climate change as part of its long term transportation planning. As it currently stands, we believe that the draft EIR on the General Plan revision does not comply with CEQA. 9

**III. The DEIR Does Not Adequately Discuss The General Plan Revision's Impact On Air Quality.**

Besides its complete failure to analyze the effects of the General Plan revision on global 10

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2. The emissions inventories in the current documentation do not include greenhouse gases. (DEIR, p. IV-33; Conservation Background Report, p. 6-93.)

warming, the DEIR also fails adequately to analyze the revision's effects on conventional air pollutants.

Air pollution is already at critical, health-endangering levels in San Bernardino County. The federal standard for ozone was exceeded on 21 days in 2002, while the state ozone standard was exceeded on 91 days.[3] Similarly, the federal and state standard for respirable particulate matter was exceeded on 98 days in 2002. (*Id.*) And, while emissions trends for most pollutants show modest decreases, particulate matter emissions are projected to *increase*, in spite of the extraordinary measures being taken by the South Coast Air Quality Management District (SCAQMD).[4] The DEIR recognizes harm to air quality as one of the significant environmental effects of the General Plan revision that cannot be fully mitigated.[5] 10

The Air Quality section of the DEIR is extremely troubling. Air quality is well known to already damage the public health in the South Coast Air Basin, with children suffering decreased lung function simply by growing up in the area. (See Bustillo, M., "Smog Harms Children's Lungs for Life, Study Finds," Los Angeles *Times*, Sept. 9, 2004, https://www.latimes.com/news/yahoo/la-me-smog9sep09,1,6309811.story.) The DEIR recognizes that the increased driving that the General Plan revision projects will further damage air quality. (DEIR, p. I-21.) Yet, this effect, although recognized as significant, receives almost no analysis or discussion in the DEIR. Effects on air quality are discussed in a bare couple of pages, in the most general terms, such as statements that new growth will occur that will cause more driving, which will in turn create more pollutant emissions. The extremely brief, non-detailed discussion of air quality is very much out of proportion to the importance, and the probable public health impacts, of the expected effects. The CEQA Guidelines require that the discussion of significant effects of a project should include discussion of direct and indirect effects, impacts on public health, and effects on the resource base. (14 Cal. Code of Regs., tit. 14 sec. 15126.2.) In general, an EIR should contain discussions sufficient to advise the decision makers and the public of the nature and importance of the environmental effects being discussed, not merely the ultimate conclusion that an effect is significant. (*Assn. of Irritated Residents v. County of Madera* (2003) 107 Cal.App.4th 1383, 1390 ("The EIR must contain facts and analysis, not just the bare conclusions of the agency. . . . . An EIR must include detail sufficient to enable those who did not participate in its preparation to understand and to consider meaningfully the issues raised by the proposed project." [Internal citations and quotation marks 11

3. Conservation Background Report, p. 6-94.

4. Conservation Background Report, p. 6-95.

5. DEIR, p. IV-27.

omitted.]) As we read the DEIR, it does not conform to this standard. 11

Where, as here, the environmental effect is harm to human health, the EIR must clearly set out the relationship between the effects of the project and the health damage that can be expected. The CEQA Guidelines, at section 15126.2, subdivision (a), require an EIR to discuss, among other things, health and safety problems caused by the physical changes that the proposed project will precipitate. The DEIR here gives its conclusion that the General Plan revision will have significant and unavoidable adverse impacts on air quality, but it does not actually discuss or disclose what those impacts can be expected to be on the health of the County's residents. The EIR is required by CEQA to do so. (*Bakersfield Citizens for Local Control v. City of Bakersfield* (2004) 124 Cal.App.4th 1184, 1219-1220.) The summary table in the DEIR that merely sets out general health effects from exposure to pollutants[6] is not sufficient; actual levels of exposure expected from execution of the General Plan revision, correlated with actual populations that will be exposed and the probable health impacts on them, is required. CEQA is not just a formal exercise, where the County can state that an effect is significant and, having set out this conclusion as though it were a magic formula, move on. The EIR must spell out what that significant effect will really consist of, to allow both the decision makers and the residents whose health, and whose children's health, will be affected, to know and understand the health damage that will result from the choices in the General Plan revision. The DEIR does not do this, and must be revised so that it does. 12

The DEIR also fails to adopt adequate mitigation for the significant adverse effects on air quality that it does identify. The mitigation measures for the County's own emissions are few and minor. Many of these mitigation measures in the DEIR seem to be measures that are *already* required by the South Coast Air Quality Management District (SCAQMD), including its requirements that publicly owned vehicle fleets must shop from among clean-fuel vehicles. Measures that the County is already legally obliged to take should be considered part of the General Plan revision, not mitigation for its effects. The SCAQMD Fleet Rules already require public agency vehicle fleets to acquire clean-fuel vehicles. Where the County is already legally obligated to undertake pollution-reducing measures, these measures should be considered to be part of the project, not as mitigation. Such measures do not lessen or avoid the environmentally harmful effects of a project, because they must already be incorporated into the project as originally designed.[7] 13

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6. DEIR, pp. IV-31-32.

7. The same principle applies to greenhouse gas emission reductions. AB 32 mandates that regulatory programs adopted under its aegis require greenhouse gas emissions reductions that are *in addition* to reductions already required by law. (Health and Saf. Code section

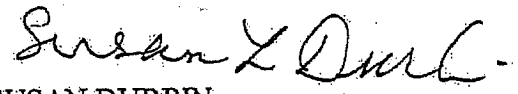
CEQA forbids public agencies to approve projects that will harm the environment until and unless the agency has adopted *all* feasible mitigation for that harm. (Public Res. Code section 21002, 21081, subdivision a.) The County must explore all feasible mitigation that could be adopted to lessen the effects of the General Plan revision, and cannot rely upon those features of the project that are already required by law to substitute for the mitigation CEQA requires. The DEIR should be revised to adopt all feasible mitigation for its air quality effects. 13

**Conclusion**

The General Plan revision is the blueprint for development in this growing, vital area of Southern California for the next 24 years, and both current residents and the half-million additional residents expected in the County by 2030 will have to live with the choices the County makes in this revision. CEQA requires that the County fully disclose, both to the decision makers and the public, all the environmental harm that may result from this blueprint. This disclosure must include the environment effects on air quality and global warming, areas in which the DEIR is currently woefully deficient, or even totally silent. We urge the County to thoroughly revise the DEIR in these areas to bring it into compliance with CEQA. 14

Thank you for the opportunity to offer these comments. Any questions may be directed to the undersigned. We also request a copy of the final EIR when it is issued.

Sincerely,



SUSAN DURBIN
Deputy Attorney General

For BILL LOCKYER
Attorney General

cc:
Kurt Weis, General Counsel
SCAQMD

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38560.5, subdivision (d)(2).

## LEAD AGENCY RESPONSE TO COMMENT LETTER S.4
## CALIFORNIA DEPARTMENT OF JUSTICE, OCTOBER 23, 2006

### RESPONSE S.4-1

The County agrees that there is a dispersion of air contaminants from one air basin to another air basin. The County believed it was appropriate to develop expanded discussions of these issues, thereby supplementing the individual responses, or acting as the responses themselves. In response to this comment, Categorical Discussions 1 and 2 are the most appropriate responses regarding the programmatic nature of the EIR and air quality analyses.

### RESPONSE S.4-2, S.4-3, S.4-4, S.4-5, S.4-6, S.4-7, S.4-8

Assembly Bill 32 will create a new regulatory program intended to reduce statewide greenhouse gas emissions to their 1990 level. It is not yet clear how, or if, these future regulations would affect local governments or how they might influence local land use planning decisions. From the background discussion in Categorical Discussion #3, it is clear that the issue of greenhouse gas reductions extends well beyond the scope of local government actions incorporated in General Plans. Nevertheless, the County of San Bernardino recognizes the importance of this issue. Goals and policies already incorporated into the General Plan will serve to reduce vehicle trip generation when compared to existing conditions. For further information, please see Categorical Discussion #3. As described in that Categorical Discussion, based on the lack of any methodologies or significance thresholds that can be applied in determining whether the impacts of the General Plan revision will be significant in terms of greenhouse gas emissions or climate change, the County believes that this EIR currently includes the proper level of disclosure for a CEQA document.

### RESPONSE S.4-9

Please see Categorical Discussion #3 for an extensive explanation absence of any methodology or agency guidance that would enable the County in this EIR or in this General Plan revision to assess or mitigate greenhouse gas emissions. The plan already includes policies to reduce emissions and those policies will help to reduce greenhouse gas emissions as well. In addition, the County respectfully disagrees with the argument that the Draft EIR should be recirculated for a second round of public review. Section 15088.5 of the CEQA Guidelines articulates the requirements for recirculation. Although the Board of Supervisors will make the final determination, none of the comments in this letter appear, from the staff's perspective to have triggered the requirements for recirculation of the Draft EIR. For further explanation, please see Categorical Discussion 6.

### RESPONSE S.4-10

The County acknowledges the commenter's opinion regarding air quality in San Bernardino County. CEQA Guidelines, §15125 require that an EIR include a description of the environment within the vicinity of a proposed project as it exists at the time the NOP/IS is published, or if no NOP/IS is published, at the time the environmental analyses commences from both a local and regional perspective. The air quality analysis in the Draft EIR was prepared at a programmatic level based on data that was the most accurate at the time the NOP/IS was published. Further, Attachment 2 includes supplemental air quality information related to the existing air quality conditions and regulatory standards specific to the County of San Bernardino. This data, however, is provided for information only and does not alter the conclusions reached in the Draft EIR.

### RESPONSE S.4-11

The County acknowledges the commenter's concern regarding air quality and public health in the County of San Bernardino. The air quality section of the Draft EIR begins on page IV-25 and continues through

page IV-36. The Draft EIR at page I-21 is only the Executive Summary. The purpose of the Executive Summary is to present the conclusions of the analysis without the detail.

The air quality analysis for the update of the General Plan for the County of San Bernardino was sufficiently prepared pursuant to the requirements outlined in the CEQA statutes beginning at Section 21000 of the California Public Resources Code, and also pursuant to the CEQA Guidelines at the California Code of Regulations, Title 14, beginning at Section 15000. Therefore, the proper analysis, evaluation of impacts, and identification of feasible mitigation measures has been accomplished in accordance with the appropriate state regulations.

The Draft EIR for this General Plan update has been prepared at a programmatic level. Program EIRs focus on policy rather than project-related impacts. They contain a more general discussion of impacts, alternatives, and mitigation measures. A General Plan EIR evaluates the large-scale impacts on the environment that can be expected to result from the adoption of the General Plan, but does not necessarily address the site-specific impacts of each of the many individual development projects that will follow and be implemented by the General Plan.

**RESPONSE S.4-12**

The County acknowledges the concerns regarding the public health concerns associated with mobile source emissions. Mobile source emissions from passenger vehicles, trucks, locomotive, ships, etc., are under the jurisdiction of the California Air Resources Control Board and EPA. These agencies currently enforce and will continue to enforce rule, regulations and controls to reduce emissions. The County of San Bernardino will adopt local, state and federal air quality regulations for both stationary and mobile source emissions in an effort to reduce air contaminants.

The impacts on the freeways and local roads are not an issue of County development, but a regional and even statewide issue. Not only growth in the County of San Bernardino, but every city within San Bernardino and surrounding counties and communities are contributing to the traffic on the regional freeway system. Preventing opportunities for growth in San Bernardino County alone will not sufficiently reduce traffic on the freeways.

Further, Attachment 2 includes supplemental air quality information related to the existing air quality conditions and regulatory standards specific to the County of San Bernardino. This data is provided for information only and does not alter the conclusions reached in the Draft EIR.

**RESPONSE S.4-13**

The County acknowledges the commentator's opinion regarding the need for additional mitigation measures to reduce the significant adverse effects on air quality. Since, the Draft EIR for the County of San Bernardino General Plan is a "Program EIR," it evaluates the broad-scale impacts of the proposed General Plan and contains a more general discussion of impacts, alternatives, and mitigation measures. The Draft EIR evaluates large-scale impacts on the environment that can be expected to result from the adoption of the General Plan, but does not necessarily address the site-specific impacts of each of the many individual development projects that may follow and be implemented by the General Plan.

The County disagrees with the comment that it is inappropriate to consider mitigation measures that are already required by the South Coast Air Quality Management District. It is common practice to include mitigation measures imposed or recommended by air quality regulatory agencies, and it is a sensible practice. The fact that such mitigation measures may be required by the District does not mean that they should not also be included as programs and policies in a general plan, as including such measures in a general plan provides an additional regulatory means of carrying out and implementing those measures.

Multiple commenter raised questions about the same or similar issues. The County believed it was appropriate to develop expanded discussions of these issues, thereby supplementing the individual responses, or acting as the responses themselves. In response to this comment, Categorical Discussions 1 and 2 are the most appropriate responses regarding the programmatic nature of the EIR and air quality analyses. Further, Attachment 2 includes supplemental air quality information related to the existing air quality conditions and regulatory standards specific to the County of San Bernardino. This data, however, is provided for information only and does not alter the conclusions reached in the Draft EIR.

**RESPONSE S.4-14**

The County respectfully disagrees that the Draft EIR's discussion on Air Quality effects is "woefully deficient." The County's position is that the air quality analysis corresponds closely to the guidance provided by the South Coast Air Quality Management District and the California Air Resources Board, both of which agencies were consulted in the preparation of the analysis. Neither agency chose to submit a letter of comment on the Draft EIR. In accordance with Section 15207 of the CEQA Guidelines, the County has concluded that these two agencies had no comments to make on the air quality analysis presented in the Draft EIR.

With regard to global warming issues, neither the California Air Resources Board nor the South Coast Air Quality Management District raised these issues during the Notice of Preparation period, nor did either agency provide comments on the Draft EIR. Categorical Discussion 3 provides further response on the analytical status of global warming issues at the present time.

# Attachment 27

# Growing Cooler: The Evidence on Urban Development and Climate Change

Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen

with Barbara McCann and David Goldberg

Urban Land Institute

Smart Growth America
Better Choices For Our Communities

Center for Clean Air Policy
Dialogue. Insight. Solutions.

National Center for Smart Growth Research & Education

*This new book documents how key changes in land development patterns could help reduce vehicle greenhouse gas emissions. Based on a comprehensive review of dozens of studies by leading urban planning researchers, the book concludes that urban development is both a key contributor to climate change and an essential factor in combating it. The authors make the case that one of the best ways to reduce vehicle travel is compact development: building places in which people can get from one place to another without driving. This includes developments with a mix of uses and pedestrian-friendly designs. Changing demographics, shrinking households, rising gas prices, and lengthening commutes are contributing to the demand for smaller homes and lots, townhouses, and condominiums near jobs and other activities. Current government policies and regulations encourage sprawling, auto-dependent development. The book recommends changes that can be made to make green neighborhoods more available and more affordable.*

*Urban Planning, approximately 60 pages, 6 x 9 Paper, $19.95 (CAN $23.95) 978-0-87420-082-9*
*Publication Date: October 2007*
*Publisher: Urban Land Institute*
*Publicity Contact: Patricia Riggs (202) 624-7086 E-mail: priggs@uli.org*
*Distributed by Independent Publishers Group*
*814 N. Franklin Street*
*Chicago, IL 60610*

# Growing Cooler: The Evidence on Urban Development and Climate Change

Reid Ewing, Keith Bartholomew, Steve Winkelman, Jerry Walters, and Don Chen

with Barbara McCann and David Goldberg

The policy recommendations presented in this book do not necessarily reflect the opinions of the Urban Land Institute.

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ISBN: 978-0-87420-082-2

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The mission of the Urban Land Institute is to provide leadership in the responsible use of land and in creating and sustaining thriving communities worldwide. ULI is committed to

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- Fostering collaboration within and beyond ULI's membership through mentoring, dialogue, and problem solving;
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## *About the Authors*

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**Keith Bartholomew** is an assistant professor of urban planning in the University of Utah's College of Architecture + Planning. An environmental lawyer, he worked for ten years as the staff attorney for 1000 Friends of Oregon, where he directed "Making the Land Use, Transportation, Air Quality Connection" (LUTRAQ), a nationally recognized research program examining the interactive effects of community development and travel behavior.

**Steve Winkelman** is director of the Transportation Program at the Center for Clean Air Policy (CCAP). He coordinated transportation analyses of climate change plans for New York and several other states, culminating in the *CCAP Transportation Emissions Guidebook*, which quantifies savings from 40 transportation policies. In February 2007 Steve launched a national discussion, "Linking Green-TEA and Climate Policy," to craft policy solutions that address travel demand.

**Jerry Walters** is a principal and chief technical officer with Fehr & Peers Associates, a California-based transportation planning and engineering firm. He directs integrated land use/transportation research and planning for public entities and real estate development interests throughout the United States and abroad.

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## *Acknowledgments*

The authors wish to thank the following individuals for contributions to this publication. The lead reviewers from the urban planning field were Arthur C. "Chris" Nelson, Virginia Polytechnic Institute, and Robert Cervero, University of California at Berkeley. From the climate community, the lead reviewers were Deron Lovaas, Natural Resources Defense Council, and Michael Replogle, Environmental Defense.

Other reviewers included Robert Dunphy from the Urban Land Institute; Geoffrey Anderson, Ilana Preuss, Megan Susman, and John Thomas of the U.S. Environmental Protection Agency; Stephen Godwin, Transportation Research Board; Megan Lewis, American Planning Association; Lee Epstein, Chesapeake Bay Foundation; Greg LeRoy, Good Jobs First; Todd Litman, Victoria Transport Institute; Matthew Johnston, Environmental and Energy Study Institute; Peter Pollock, Lincoln Institute of Land Policy; Robert Johnston, University of California at Davis; Mark Muro, Brookings Institution; Scott Bernstein, Center for Neighborhood Technology; Peter Newman, Murdoch University; Brian Orland, Penn State University; Naomi Friedman, Metropolitan Washington Council of Governments; Shelley Poticha and Mariia Zimmerman, Reconnecting America; Jody McCullough, Rob Kafalenos, Kevin Black, David Kuehn, Ed Weiner, and Jack Wells, U.S. Federal Highway Administration; John Holtzclaw, Sierra Club; Kurt Culbertson, American Society of Landscape Architects; Rich McClintock, University of Colorado at Denver; Kaid Benfield, Natural Resources Defense Council; Larry Frank, University of British Columbia; and Judy Corbett, Local Government Commission.

Stephanie Potts and Kate Rube of Smart Growth America helped with logistics. Shala White and Meghan Ewing produced graphic materials. The U.S. Environmental Protection Agency (EPA), the National Endowment for the Arts (NEA), and the William and Flora Hewlett Foundation funded the research. The Governors' Institute on Community Design also assisted in the development of the book.

Reid Ewing
College Park, Maryland

# Contents


## *Executive Summary*

Driving Up $CO_2$ Emissions
Changing Development Patterns to Slow Global Warming
The Potential for Smart Growth
A Climate-Sparing Strategy with Multiple Payoffs
Policy Recommendations

## *1. Introduction*

1.1 Background
1.2 The Nature of Compact Development
1.3 The High Costs of Urban Sprawl and Automobile Dependence
1.4 A Perfect Storm in Climate Policy
1.5 A Perfect Storm in Consumer Demand
1.6 And a Perfect Storm in Urban Planning
1.7 The Impact of Compact Development on VMT and $CO_2$ Emissions
- 1.7.1 Market Share of Compact Development
- 1.7.2 Reduction in VMT per Capita with Compact Development
- 1.7.3 Increment of New Development or Redevelopment Relative to the Base
- 1.7.4 Proportion of Weighted VMT within Urban Areas
- 1.7.5 Ratio of $CO_2$ to VMT Reduction
- 1.7.6 Proportion of Transport $CO_2$ from Motor Vehicles
- 1.7.7 Net $CO_2$ Reduction in Comparison to Other Actions

1.8 The Organization of this Report

## *2. The VMT/$CO_2$/Climate Connection*

2.1 Prospects for the U.S. Transportation Sector
2.2 VMT and $CO_2$ Projections
2.3 Other Influences on $CO_2$ Emissions
- 2.3.1 Vehicle Trip Frequencies
- 2.3.2 Vehicle Operating Speeds
- 2.3.3 Synthesis

## *3. The Urban Environment/VMT Connection*

3.1 Aggregate Travel Studies
- 3.1.1 Measuring Urban Sprawl
- 3.1.2 Relating Urban Sprawl to Travel Outcomes
- 3.1.3 Sprawl versus VMT
- 3.1.4 Sprawl versus Congestion

3.2 Disaggregate Travel Studies
- 3.2.1 Accessibility Again
- 3.2.2 Measuring the Five Ds
- 3.2.3 D Variables versus VMT and VT
- 3.2.4 Meta-Analysis of Disaggregate Travel Studies

3.3 Regional Growth Simulations
3.3.1 The Rise of Scenario Planning
3.3.2 The Scenario Planning Process
3.3.3 Case Study: Sacramento Region Blueprint Study
3.3.4 A Sample of Regional Scenario Studies
3.3.5 Differences across Scenarios
3.3.6 Meta-Analysis of Regional Simulation Studies
3.3.7 The Conservative Nature of Scenario Forecasts
3.3.8 Regional Growth and Vehicle Emissions
3.3.9 Regional Growth and Transportation Pricing
3.4 Project-Level Simulations
3.4.1 Case Study: Atlantic Steel Project XL
3.4.2 Site Plan Influences on VMT
3.4.3 Regional Location Influences on VMT
3.4.4 The Relationship between VMT Reduction and $CO_2$ Reduction

***4. Environmental Determinism versus Self Selection***

4.1 The Empirical Literature on Self Selection
4.2 The Built Environment May Matter in any Case

***5. Induced Traffic and Induced Development***

5.1 Case Study: Interstate 270
5.2 The Magnitude of Induced Traffic
5.3 The Role of Induced Development
5.4 Historical Changes in Induced Development
5.5 What Is Known about Induced Development

***6. The Residential Sector***

***7. Policy and Program Recommendations***

[NOTE: THIS CHAPTER IS STILL IN PRELIMINARY FORM AND IS SUBJECT TO CHANGE]

7.1 Federal Policy Recommendations
7.1.1 Require Transportation Conformity for Greenhouse Gases
7.1.2 Use Cap-and-Trade (or Carbon Tax) Revenues to Promote Infill Development
7.1.3 Enact "Green-TEA" Transportation Legislation that Reduces GHGs
7.1.4 Replace Funding Formulas with Funding Based on Progress toward National Goals
7.1.5 Provide Funding Directly to Metropolitan Planning Organizations
7.1.6 Develop a National Blueprint Planning Process that Encourages Transportation Choices and Better System Management
7/1/7 Place More Housing within Reach
7.1.8 Create a New Program to Provide Funding to "Rewrite the Rules"
7.2 State Policy Recommendations
7.2.1 Set Targets for Vehicle-Miles of Travel

7.2.2 Adopt Transportation and Land Use Policies that Support Climate Goals
7.2.3 Align Spending with Climate and Smart Growth Goals
7.2.4 Create Economic Development Incentives
7.2.5 Eliminate Perverse Local Growth Incentives
7.3 Regional and Local Policy Recommendations
7.3.1 Change the Development Rules
7.3.2 Favor Good Projects in the Approval Process
7.3.3 Prioritize and Coordinate Funding to Support Infill Development
7.3.4 Make Transit, Pedestrians, and Bikes an Integral Part of Community Development
7.3.5 Invest in Civic Engagement and Education
7.4 Developing a Comprehensive Policy Package

***8. Conclusion***

***References***

# Executive Summary

The phrase "you can't get there from here" has a new application. For climate stabilization, a commonly accepted target would require the United States to cut its carbon dioxide ($CO_2$) emissions by 60 to 80 percent as of 2050, relative to 1990 levels. Carbon dioxide levels have been increasing rapidly since 1990, and so would have to level off and decline even more rapidly to reach this target level by 2050. This publication demonstrates that the U.S. transportation sector cannot do its fair share to meet this target through vehicle and fuel technology alone. We have to find a way to sharply reduce the growth in vehicle miles driven across the nation's sprawling urban areas, reversing trends that go back decades.

This publication is based on an exhaustive review of existing research on the relationship between urban development, travel, and the $CO_2$ emitted by motor vehicles. It provides evidence on and insights into how much transportation-related $CO_2$ savings can be expected with compact development, how compact development is likely to be received by consumers, and what policy changes will make compact development possible. Several related issues are not fully examined in this publication. These include the energy savings from more efficient building types, the value of preserved forests as carbon sinks, and the effectiveness of pricing strategies—such as tolls, parking charges, and mileage-based fees—when used in conjunction with compact development and expanded transportation alternatives.

The term "compact development" does not imply high-rise or even uniformly high density, but rather higher average "blended" densities. Compact development also features a mix of land uses, development of strong population and employment centers, interconnection of streets, and the design of structures and spaces at a human scale.

**The Basics**

Scientific consensus now exists that greenhouse gas accumulations due to human activities are contributing to global warming with potentially catastrophic consequences (IPCC 2007). International and domestic climate policy discussions have gravitated toward the goal of limiting the temperature increase to 2°C to 3°C by cutting greenhouse gas emissions by 60 to 80 percent below 1990 levels by the year 2050. The primary greenhouse gas is carbon dioxide, and every gallon of gasoline burned produces about 20 pounds of $CO_2$ emissions.

## *Driving Up $CO_2$ Emissions*

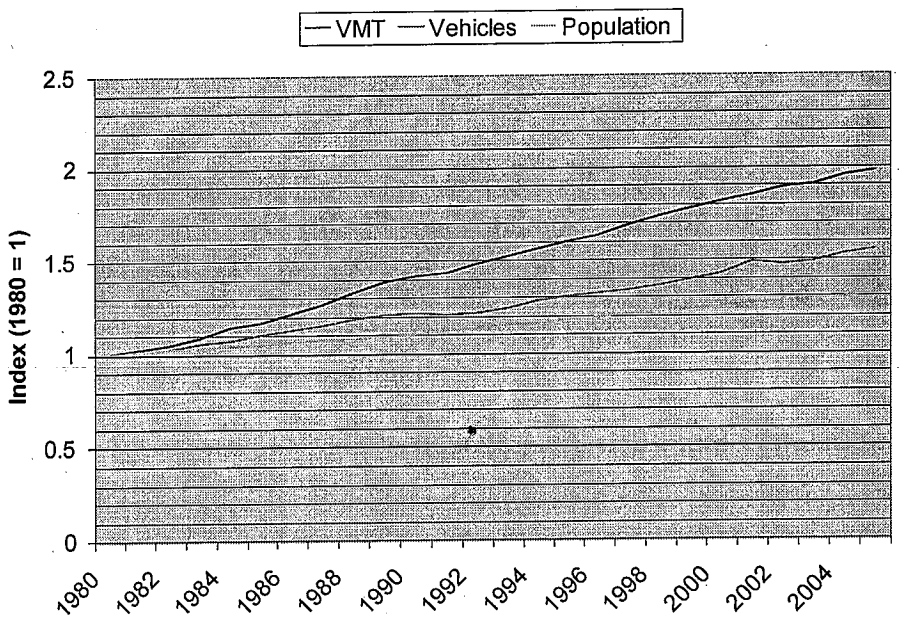
The United States is the largest emitter worldwide of the greenhouses gases that cause global warming. Transportation accounts for a full third of $CO_2$ emissions in the United States, and that share is growing as others shrink in comparison, rising from 31 percent in 1990 to 33 percent today It is hard to envision a "solution" to the global warming crisis that does not involve slowing the growth of transportation $CO_2$ emissions in the United States.

## The Three-Legged Stool Needed to Reduce CO2 from Automobiles

Transportation CO2 reduction can be viewed as a three-legged stool, with one leg related to vehicle fuel efficiency, a second to the carbon content of the fuel itself, and a third to the amount of driving or vehicle miles traveled (VMT). Energy and climate policy initiatives at the federal and state levels have pinned their hopes almost exclusively on shoring up the first two legs of the stool, through the development of more efficient vehicles (such as hybrid cars) and lower-carbon fuels (such as biodiesel fuel). Yet a stool cannot stand on only two legs.

As the research compiled in this publication makes clear, technological improvement in vehicles and fuels are likely to be offset by continuing, robust growth in VMT. Since 1980, the number of miles Americans drive has grown three times faster than the U.S. population, and almost twice as fast as vehicle registrations (see Figure 0-1). Average automobile commute times in metropolitan areas have risen steadily over the decades, and many Americans now spend more time commuting than they do vacationing.

**Figure 0-1 Growth of VMT, Vehicle Registrations, and Population in the United States relative to 1980 Values**
*Source: FHWA 2005.*




This raises some questions, which this report addresses. Why do we drive so much? Why is the total distance we drive growing so rapidly? And what can be done to alter this trend in a manner that is effective, fair, and economically acceptable?

The growth in driving is due in large part to urban development, or what some refer to as the built environment. Americans drive so much because we have given ourselves little alternative. For 60 years, we have built homes ever farther from workplaces, created schools that are inaccessible except by motor vehicle, and isolated other destinations—such as shopping—from

work and home. From World War II until very recently, nearly all new development has been planned and built on the assumption that people will use cars virtually every time they travel. As a larger and larger share of our built environment has become automobile dependent, car trips and distances have increased, and walking and public transit use have declined. Population growth has been responsible for only a quarter of the increase in vehicle miles driven over the last couple of decades. A larger share of the increase can be traced to the effects of a changing urban environment, namely to longer trips and people driving alone.

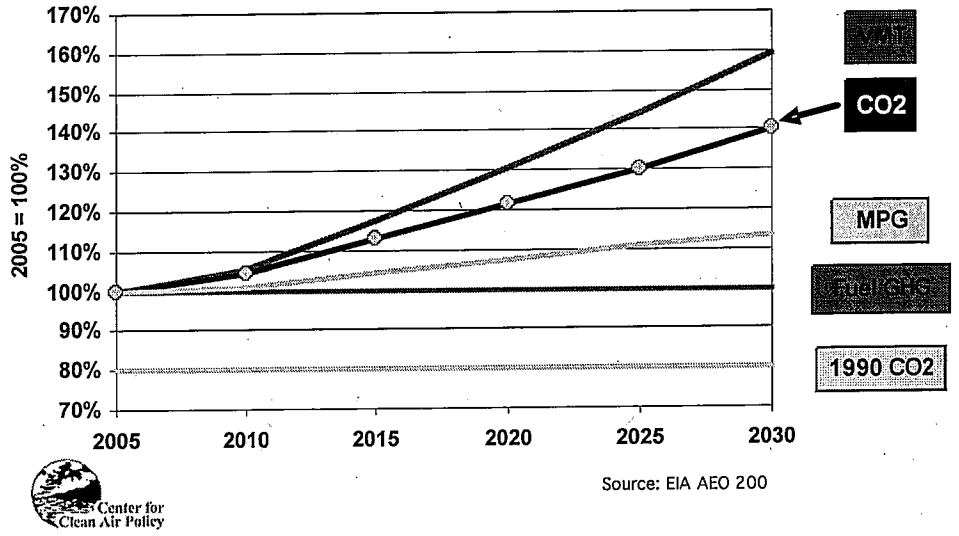
As with driving, land is being consumed for development at a rate almost three times faster than population growth. This expansive development has caused $CO_2$ emissions from cars to rise even as it has reduced the amount of forest land available to absorb $CO_2$.

## How Growth in Driving Cancels Out Improved Vehicle Fuel Economy

Carbon dioxide is more difficult to control through vehicle technology than are conventional air pollutants. Conventional pollutants can be reduced in automobile exhaust with sophisticated emission control systems (catalytic converters, on-board computers, and oxygen sensors). Carbon dioxide, meanwhile, is a direct outcome of burning fossil fuels; there is no practical way to remove or capture it from moving vehicles. At this point in time, the only way to reduce $CO_2$ emissions from vehicles is to burn less gasoline and diesel fuel.

An analysis by Steve Winkelman of the Center for Clean Air Policy, one of the coauthors of this publication, finds that $CO_2$ emissions will continue to rise, despite technological advances, as the growth in driving overwhelms planned improvements in vehicle efficiency and fuel carbon content. The U.S. Department of Energy's Energy Information Administration (EIA) forecasts that driving will increase 59 percent between 2005 and 2030 (red line, Figure 0-2), outpacing the projected 23 percent increase in population. The EIA also forecasts a fleetwide fuel economy improvement of 12 percent within this time frame, primarily as a result of new federal fuel economy standards for light trucks (green line, Figure 0-2). Despite this improvement in efficiency, $CO_2$ emissions would grow by 41 percent (dark blue line, Figure 0-2).

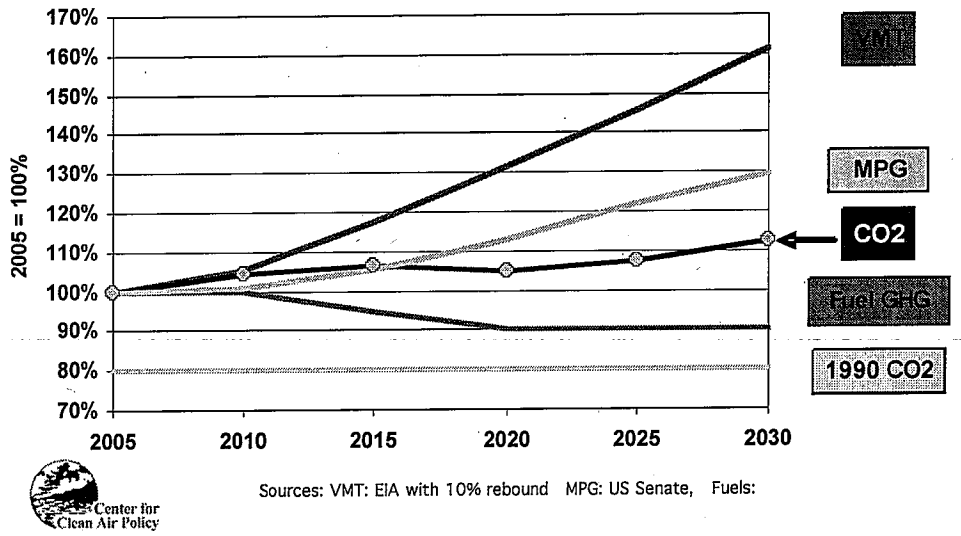
**Figure 0-2 Projected Growth in $CO_2$ Emissions from Cars and Light Trucks**
*Source: EIA 2007.*



U.S. fuel economy has been flat for almost 15 years, as the upward spiral of car weight and power has offset the more efficient technology. Federal and state efforts are underway to considerably boost vehicle efficiency and reduce greenhouse gas emissions. In June 2007, the U.S. Senate passed corporate average fuel economy (CAFE) standards that would increase new passenger vehicle fuel economy from the current 25 miles per gallon (mpg) to 35 mpg by 2020. (As of this writing, the House has not acted.). California plans to implement a low carbon standard for transportation fuels, specifically a 10 percent reduction in fuel carbon content by 2020.

Even if these more stringent standards for vehicles and fuels were to go into effect nationwide, transportation-related emissions would still far exceed target levels for stabilizing the global climate (see Figure 0-3). The rapid increase in driving would overwhelm both the increase in vehicle fuel economy (green line) and the lower carbon fuel content (purple line). In 2030, $CO_2$ emissions would be 12 percent *above* the 2005 level, and 40 percent above the 1990 level (turquoise line). For climate stabilization, the United States must bring the $CO_2$ level to 15 to 30 percent *below* 1990 levels by 2020 to keep in play a $CO_2$ reduction of 60 to 80 percent by 2050.

**Figure 0-3 Projected Growth in $CO_2$ Emissions from Cars and Light Trucks Assuming Stringent Nationwide Vehicle and Fuel Standards***
*Source: EIA 2007*




As the projections show, the United States cannot achieve such large reductions in transportation-related $CO_2$ emissions without sharply reducing the growth in miles driven.

## *Changing Development Patterns to Slow Global Warming*

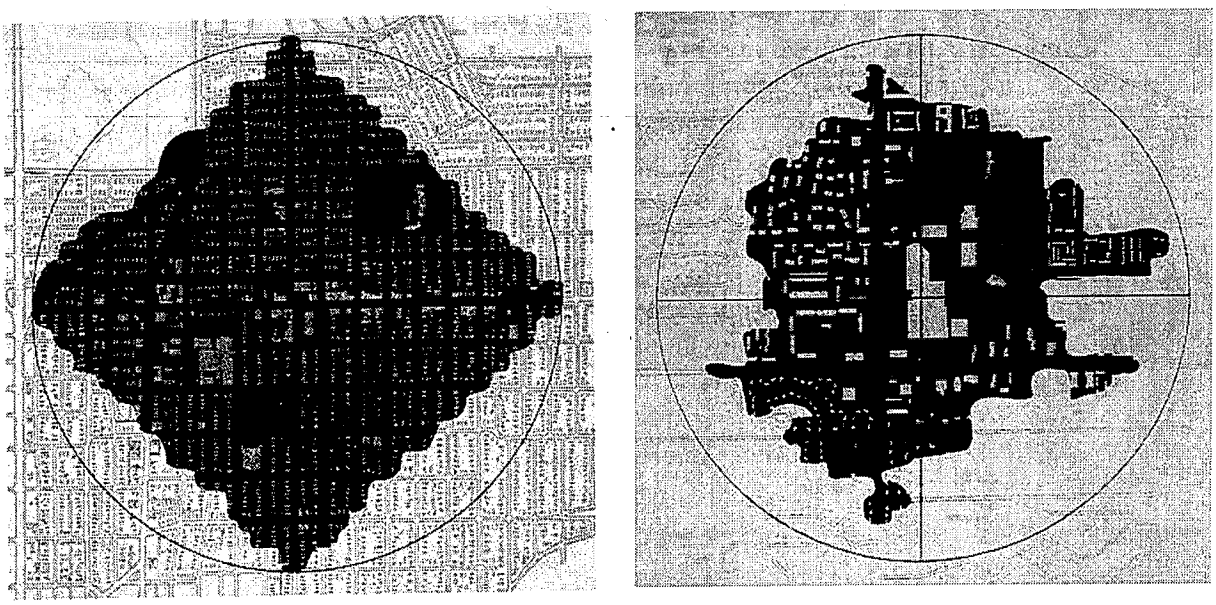
Recognizing the unsustainable growth in driving, the American Association of State Highway and Transportation Officials (AASHTO), representing state departments of transportation, is urging that the growth of vehicle miles driven be cut in half. How does a growing country—one with 300 million residents and another 100 million on the way by mid-century—slow the growth of vehicle miles driven?

Aggressive measures certainly are available, including imposing ever stiffer fees and taxes on driving and parking or establishing no-drive zones or days. Some countries are experimenting with such measures. However, many in this country would view such steps as punitive, given the reality that most Americans do not have a viable alternative to driving. The body of research surveyed here shows that much of the rise in vehicle emissions can be curbed simply by growing in a way that will make it easier for Americans to drive less. In fact, the weight of the evidence shows that, with more compact development, people drive 20 to 40 percent less, at minimal or reduced cost, while reaping other fiscal and health benefits.

## How Compact Development Helps Reduce the Need to Drive

Better community planning and more compact development help people live within walking or bicycling distance of some of the destinations they need to get to every day—work, shops, schools, and parks, as well as transit stops. If they choose to use a car, trips are short. Rather than building single-use subdivisions or office parks, communities can plan mixed-use developments that put housing within reach of these other destinations. The street network can be designed to interconnect, rather than end in culs-de-sac and funnel traffic onto overused arterial roads. Individual streets can be designed to be "complete," with safe and convenient places to walk, bicycle, and wait for the bus. Finally, by building more homes as condominiums, townhouses, or detached houses on smaller lots, and by building offices, stores and other destinations "up" rather than "out," communities can shorten distances between destinations. This makes neighborhood stores more economically viable, allows more frequent and convenient transit service, and helps shorten car trips.

**Figure 0-4 Destinations within One-Quarter Mile of Center for Contrasting Street Networks in Seattle**
*Source: Moudon et al. 1997.*



This type of development has seen a resurgence in recent years, and goes by many names, including "walkable communities," "new urbanist neighborhoods," and "transit-oriented developments" (TODs). "Infill" and "brownfield" developments put unused lots in urban areas to new uses, taking advantage of existing nearby destinations and infrastructure. Some "lifestyle centers" are now replacing single-use shopping malls with open-air shopping on connected streets with housing and office space as part of the new development. And many communities have rediscovered and revitalized their traditional town centers and downtowns, often adding more housing to the mix. These varied development types are collectively referred to in this publication as "compact development" or "smart growth."

## How We Know that Compact Development Will Make a Difference: The Evidence

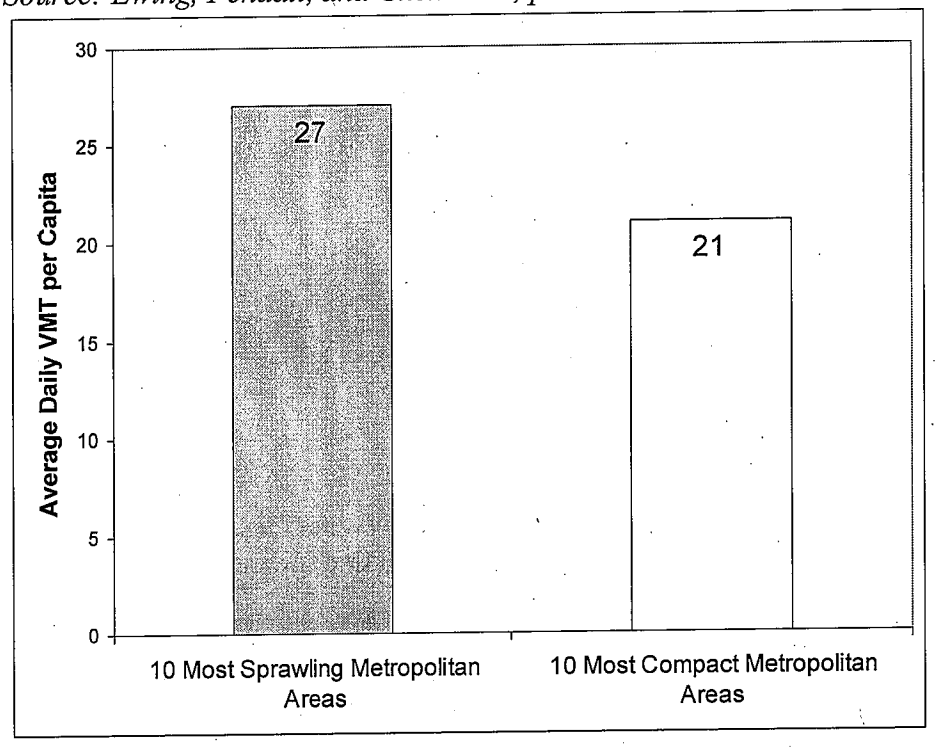
As these forms of development have become more common, planning researchers and practitioners have documented that residents of compact, mixed-use, transit-served communities do less driving. Studies have looked at the issue from varying angles, including:

- research that compares overall travel patterns among regions and neighborhoods of varying compactness and auto orientation;
- studies that follow the travel behavior of individual households in various settings; and
- models that simulate and compare the effects on travel of different future development scenarios at the regional and project levels.

Regardless of the approach, researchers have found significant potential for compact development to reduce the miles that residents drive.

A comprehensive sprawl index developed by coauthor Reid Ewing of the National Center for Smart Growth at the University of Maryland ranked 83 of the largest metropolitan areas in the United States by their degree of sprawl, measuring density, mix of land uses, strength of activity centers, and connectedness of the street network (Ewing, Pendall, and Chen 2002, 2003). Even accounting for income and other socioeconomic differences, residents drove far less in the more compact regions. In highly sprawling Atlanta, vehicles racked up 34 miles each day for every person living in the region. Toward the other end of the scale, in Portland, Oregon, vehicles were driven fewer than 24 miles per person, per day.

**Figure 0-5 Average Daily Vehicle Miles Traveled**
*Source: Ewing, Pendall, and Chen 2002, p. 18.*




This relationship holds up in studies that focus on the travel habits of individual households while measuring the environment surrounding their homes and/or workplaces. The link between urban development patterns and individual or household travel has become the most heavily researched subject in urban planning, with more than 100 rigorous empirical studies completed. These studies have been able to control for factors such as socioeconomic status, and can account for the fact that higher-income households tend to make more and longer trips than lower-income families.

One of the most comprehensive studies, conducted in King County, Washington, by Larry Frank of the University of British Columbia, found that residents of the most walkable neighborhoods drive 26 percent fewer miles per day than those living in the most sprawling areas. A meta-analysis of many of these types of studies finds that households living in developments with twice the density, diversity of uses, accessible destinations, and interconnected streets when compared to low-density sprawl drive about 33 percent less.

Many studies have been conducted by or in partnership with public health researchers interested in how the built environment can be better designed to encourage daily physical activity. These studies show that residents of communities designed to be walkable both drive fewer miles and also take more trips by foot and bicycle, which improves individual health. A recent literature review found that 17 of 20 studies, all dating from 2002 or later, have established statistically significant relationships between some aspect of the built environment and the risk of obesity.

Two other types of studies also find relationships between development patterns and driving: simulations that project the effect of various growth options for entire regions and simulations that predict the impact of individual development projects when sited and designed in different ways. In regional growth simulations, planners compare the effect of a metropolitan-wide business-as-usual scenario with more compact growth options. Coauthor Keith Bartholomew of the University of Utah analyzed 23 of these studies and found that compact scenarios averaged 8 percent fewer total miles driven than business-as-usual ones, with a maximum reduction of 31.7 percent (Bartholomew 2005, 2007). The better-performing scenarios were those with higher degrees of land use mixing, infill development, and population density, as well as a larger amount of expected growth. The travel models used in these studies would be expected to underestimate the impacts of site design, since most only crudely account for travel within neighborhoods and disregard walk and bike trips entirely.

Of the project-level studies, one of the best known evaluated the impact of building a very dense, mixed-use development at an abandoned steel mill site in the heart of Atlanta versus spreading the equivalent amount of commercial space and number of housing units in the prevailing patterns at three suburban locations. Analysis using transportation models enhanced by coauthor Jerry Walters of Fehr & Peers Associates (Walters, Ewing, and Allen 2000), and supplemented by the EPA's Smart Growth Index (to capture the effects of site design) found that the infill location would generate about 35 percent less driving and emissions than the comparison sites. The results were so compelling that the development was deemed a transportation control measure by the federal government for the purpose of helping to improve the region's air quality. The Atlantic Station project has become a highly successful reuse of central city industrial land.

**Atlantic Station today.**
*Jacoby Development Company*

### What Smart Growth Would Look Like

How would this new focus on compact development change U.S. communities? Many more developments would look like the transit-oriented developments and new urbanist neighborhoods already going up in almost every city in the country, and these developments would start filling in vacant lots or failing strip shopping centers, or would revitalize older town centers, rather than replacing forests or farmland. Most developments would no longer be single-use subdivisions or office parks, but would mix shops, schools, and offices together with homes. They might feature ground-floor stores and offices with living space above, or townhomes within walking distance of a retail center. Most developments would be built to connect seamlessly with the external street network.

The density increases required to achieve the changes proposed in this publication would be moderate. Nelson's work shows that the average density of residential development in U.S. urban areas was about 7.6 units per acre in 2003. His predictions of shifting market demand indicate that all housing growth to 2025 could be accommodated by building condominiums, apartments, townhomes, and detached houses on small lots, while maintaining the current stock of houses on large lots. Under this scenario, while new developments would average a density of 13 units per acre, the average density of metropolitan areas overall would rise modestly, to about nine units per acre. Much of the change would result from stopping the sprawling development that has resulted in falling densities in many metropolitan areas.

Several publications provide a glimpse of what this future might look like. Images of compact development are available in *This is Smart Growth* (Smart Growth Network 2006) and *Visualizing Density* (Lincoln Institute of Land Policy 2007).

## *The Potential of Smart Growth*

The potential of smart growth to curb the rise in greenhouse gas emissions will, of course, be limited by the amount of new development and redevelopment that takes place over the next few decades, and by the share of it that is compact in nature. There seems to be little question that a great deal of new building will take place as the U.S. population grows toward 400 million. According to the best available analysis, by Chris Nelson of Virginia Tech, 89 million new or replaced homes—and 190 billion square feet of new offices, institutions, stores, and other nonresidential buildings—will be constructed through 2050. If that is so, two-thirds of the development on the ground in 2050 will be built between now and then. Pursuing smart growth is a low-cost climate change strategy, because it involves shifting investments that have to be made anyway.

### Smart Growth Meets Growing Market Demand for Choice

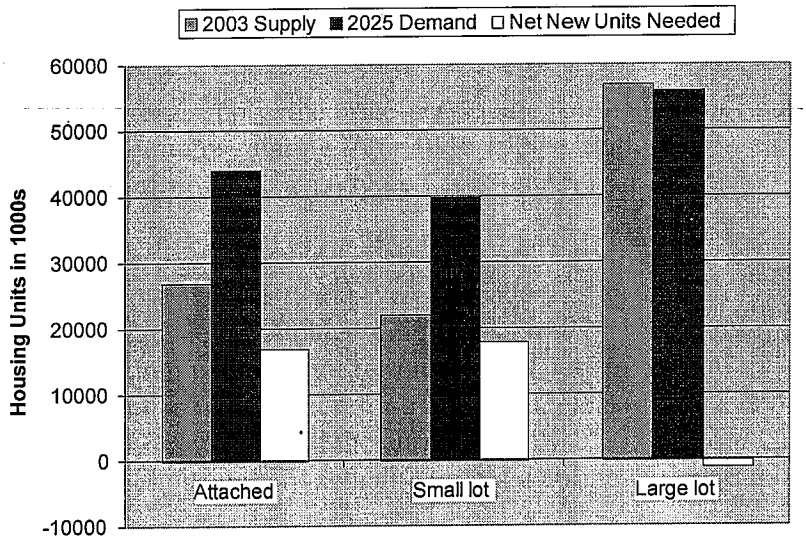
There is no doubt that moving away from a fossil fuel–based economy will require many difficult changes. Fortunately, smart growth is a change that many Americans will embrace. Evidence abounds that Americans are demanding more choices in where and how they live—and that changing demographics will accelerate that demand.

While prevailing zoning and development practices typically make sprawling development easier to build, developers who make the effort to create compact communities are encountering a responsive public. In 2003, for the first time in the country's history, the sales prices per square foot for attached housing—that is, condominiums and townhouses—was higher than that of detached housing units. The real estate analysis firm Robert Charles Lesser & Co. has conducted a dozen consumer preference surveys in suburban and urban locations[1] for a variety of builders to help them develop new projects. The surveys have found that in every location examined, about one-third of respondents prefer smart growth housing products and communities. Other studies by the National Association of Homebuilders, the National Association of Realtors, the Fannie Mae Foundation, high-production builders, and other researchers have corroborated these results—some estimating even greater demand for smart growth housing products. When smart growth also offers shorter commutes, it appeals to another one-quarter of the market, because many people are willing to trade lot or house size for shorter commutes.

Because the demand is greater than the current supply, the price-per-square foot values of houses in mixed-use neighborhoods show price premiums ranging from 40 to 100 percent, compared to houses in nearby single-use subdivisions, according to a study by Chris Leinberger of the Brookings Institution.

This market demand is only expected to grow over the next several decades, as the share of households with children shrinks and those made up of older Americans grows with the retiring of baby boomers. Households without children will account for close to 90 percent of new housing demand, and single-person households will account for a one-third. Nelson projects that the demand for attached and small-lot housing will exceed the current supply by 35 million units (71 percent), while the demand for large-lot housing will actually be less than the current supply.

**Figure 0-6 2003 Housing Supply versus 2025 Housing Demand**
*Source: Nelson 2006.*




[1] These locations include Albuquerque, Atlanta, Boise, Charlotte, Chattanooga, Denver, Orlando, Phoenix, Provo, Savannah, and Tampa.

## *Total Estimated VMT Reduction and Total Climate Impact*

When viewed in total, the evidence on land use and driving shows that compact development will reduce the need to drive between 20 and 40 percent, as compared with development on the outer suburban edge with isolated homes, workplaces, and other destinations. It is realistic to assume a 30 percent cut in VMT with compact development.

Making reasonable assumptions about growth rates, the market share of compact development, and the relationship between $CO_2$ reduction and VMT reduction, smart growth could, by itself, reduce total transportation-related $CO_2$ emissions from current trends by 7 to 10 percent as of 2050. This reduction is achievable with land-use changes alone. It does not include additional reductions from complementary measures, such as higher fuel prices and carbon taxes, peak-period road tolls, pay-as-you drive insurance, paid parking, and other policies designed to make drivers pay more of the full social costs of auto use.

This estimate also does not include the energy saved in buildings with compact development, or the $CO_2$-absorbing capacity of forests preserved by compact development. Whatever the total savings, it is important to remember that land use changes provide a permanent climate benefit that would compound over time. The second 50 years of smart growth would build on the base reduction from the first 50 years, and so on into the future. More immediate strategies, such as gas tax increases, do not have this degree of permanence.

The authors calculate that shifting 60 percent of new growth to compact patterns would save 85 million metric tons of $CO_2$ annually by 2030. The savings over that period equate to a 28 percent increase in federal vehicle efficiency standards by 2020 (to 32 mpg), comparable to proposals now being debated in Congress. It would be as if the fleetwide efficiency for new vehicles had risen to 32 mpg by 2020. Every resident of a compact neighborhood would provide the environmental benefit expected from, say, driving one of today's efficient hybrid cars. That effect would be compounded, of course, if that person also drove such an efficient car whenever he or she chose to make a vehicle trip. Smart growth would become an important "third leg" in the transportation sector's fight against global warming, along with more efficient vehicles and lower-carbon fuels.

## *A Climate-Sparing Strategy with Multiple Payoffs*

Addressing climate change through smart growth is an attractive strategy because, in addition to being in line with market demand, compact development provides many other benefits and will cost the economy little or nothing. Research has documented that compact development helps preserve farmland and open space, protect water quality, and improve health by providing more opportunities for physical activity.

Studies also have confirmed that compact development saves taxpayers money, particularly by reducing the costs of infrastructure such as roads and water and sewer lines. For example, the Envision Utah scenario planning process resulted in the selection of a compact growth plan that will save the region about $4.5 billion in infrastructure spending over a continuation of sprawling development.

Finally, unlike hydrogen-fueled vehicles and cellulosic ethanol, which get a lot of attention in the climate-change debate, the "technology" of compact, walkable communities exists today, as it has in one form or another for thousands of years. We can begin using this technology in the service of a cooler planet right now.

## Policy Recommendations

In most metropolitan areas, compact development faces an uneven playing field. Local land development codes encourage auto-oriented development. Public spending supports development at the metropolitan fringe more than in already developed areas. Transportation policies remain focused on accommodating the automobile rather than alternatives.

The key to substantial greenhouse gas (GHG) reductions is to get all policies, funding, incentives, practices, rules, codes, and regulations pointing in the same direction to create the right conditions for smart growth. Innovative policies often are in direct conflict with the conventional paradigm that produces sprawl and automobile dependence.

Here, we outline three major policy initiatives at the federal level that would benefit states, metro regions, cities and towns in their efforts to meet the growing demand for compact development. These initiatives, as well as potential actions on the part of state and local governments, are discussed more fully in Chapter 7.

### Federal Actions

***Require Transportation Conformity for Greenhouse Gases.*** Federal climate change legislation should require regional transportation plans to pass a conformity test for $CO_2$ emissions, similar to those for other criteria pollutants. The Supreme Court ruling in Massachusetts v EPA established the formal authority to consider greenhouse gases under the Clean Air Act, and a transportation planning conformity requirement would be an obvious way for the EPA to exercise this authority to produce tangible results.

***Enact "Green-TEA" Transportation Legislation that Reduces GHGs.*** The Intermodal Surface Transportation Efficiency Act of 1991 (known as ISTEA) represented a revolutionary break from past highway bills with its greater emphasis on alternatives to the automobile, community involvement, environmental goals, and coordinated planning. The next surface transportation bill could bring yet another paradigm shift; it could further address environmental performance, climate protection, and green development. We refer to this opportunity as "Green-TEA."

***Provide Funding Directly to Metropolitan Planning Organizations (MPOs).*** Metropolitan areas contain more than 80 percent of the nation's population and 85 percent of its economic output. Investment by state departments of transportation in metropolitan areas lags far behind these percentages. The issue is not just the amount of funding; it is also the authority to decide how the money is spent. What is necessary to remedy the long history of structural and institutional causes of these inequities is a new system of allocating federal transportation funds directly to metropolitan areas. The amount of allocation should be closer to the proportion of an MPO's population and economic activity compared to other MPOs and non-MPO areas in the same state.

## 1. Introduction

The phrase "you can't get there from here" has a new application. The United States cannot achieve a 60 to 80 percent reduction in carbon dioxide ($CO_2$) emissions by 2050 relative to 1990 levels—a commonly accepted target for climate stabilization—unless the transportation sector contributes, and the transportation sector cannot do its fair share through vehicle and fuel technology alone. We have to sharply reduce the growth of vehicular travel across the nation's sprawling urban areas, reversing trends that go back decades.

With regard to urban development and travel demand management, this publication asks and answers three critical questions facing the urban planning profession, the land development community, and federal, state, and local policy makers:

- What reduction in vehicle miles traveled (VMT) is possible in the United States with compact development rather than continuing urban sprawl?
- What reduction in $CO_2$ emissions will accompany such a reduction in VMT?
- What policy changes will be required to shift the dominant land development pattern from sprawl to compact development?

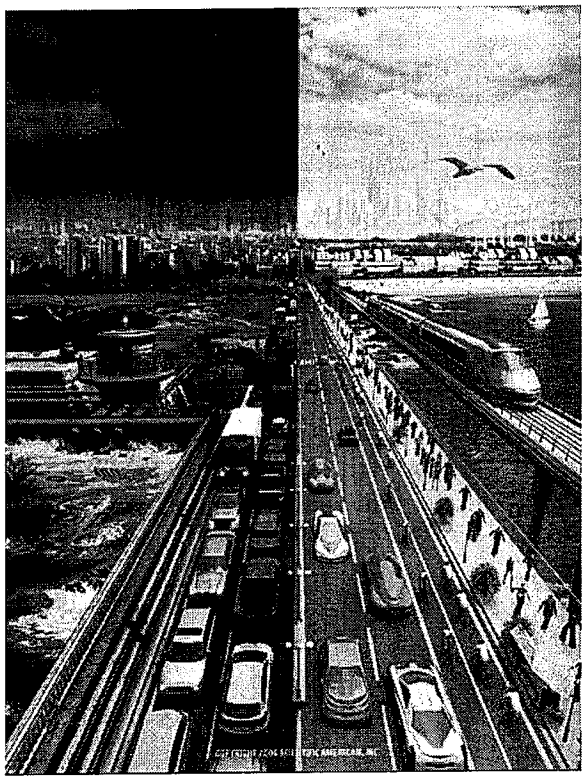
### 1.1 Background

The transportation sector accounts for 28 percent of total greenhouse gas (GHG) emissions in the United States and 33 percent of the nation's energy-related $CO_2$ emissions (EIA 2006, p. xvi; EIA 2007a, p. 15). The United States, in turn, is responsible for 22 percent of $CO_2$ emissions worldwide and close to a quarter of worldwide GHG emissions (EIA 2007b, p. 93). It is hard to envision a "solution" to the global warming crisis that does not involve slowing the growth of transportation $CO_2$ emissions in the United States

The transportation sector's $CO_2$ emissions are a function of vehicle fuel efficiency, fuel carbon content, and VMT, factors sometimes referred to as a "three-legged stool." Energy and climate policy initiatives at the federal and state levels have focused almost exclusively on technological advances in vehicles and fuels, the first two legs. Yet, there is a growing recognition that managing VMT has to be part of the solution, that the third leg is needed to support the stool.

In *A Call for Action*, the U.S. Climate Action Partnership (USCAP)—which is made up of major U.S. corporations and environmental groups—includes promoting "better growth planning" (USCAP 2007). The United Nations Intergovernmental Panel on Climate Change (IPCC 2007c, p. 20) lists "influenc[ing] mobility needs through land use regulations and infrastructure planning" among policies and measures shown to be effective in controlling GHG emissions." California's Climate Action Team (2007) expects "smart land use and intelligent transportation" to make the second-largest contribution toward meeting the state's ambitious GHG reduction goals.

The architects of the principal GHG stabilization framework are banking on major changes in urban development and travel patterns. "The task of holding global emissions constant would be out of reach, were it not for the fact that all the driving and flying in 2056 will be in vehicles not yet designed, most of the buildings that will be around then are not yet built, the locations of many of the communities that will contain these buildings and determine their inhabitants' commuting patterns have not yet been chosen . . ." (Socolow and Pacala 2006).



**Alternative futures, circa 2056.**
© Scientific American (Socolow and Pacala 2006)

A recent report by the U.S. Environmental Protection Agency (EPA) finds: "By themselves, individual approaches incorporating vehicle technologies, fuels, or transportation demand management (TDM) approaches could moderately reduce, but not flatten, emissions from now until 2050. Most of the system approaches analyzed, by contrast, could . . . nearly flatten the entire U.S. transportation sector emissions, despite the passenger vehicle category representing only half of the sector's emissions" (Mui et al. 2007). In other words, all three legs of the policy stool will be required to flatten transportation $CO_2$ emission levels.

## *1.2 The Nature of Compact Development*

This publication makes the case for compact development—or its alias, smart growth—rather than continued urban sprawl. It does so in the context of global climate change.

The term "compact development" does not imply high-rise or even uniformly high-density development. A discussion of alternatives to urban sprawl always seems to gravitate toward high-density development, and leads to fears that more compact development will result in the "Manhattanization" of America. That is not what this book is about.

According to data provided by Chris Nelson of Virginia Tech, the blended average density of residential development in the United States in 2003 was about 7.6 units per net acre (see Figure 1-1). This estimate includes apartments, condominiums, and townhouses, as well as detached single-family housing on both small and large lots. A net acre is an acre of developed land, not including streets, school sites, parks, and other undevelopable land.

Because of changing demographics and lifestyle preferences, Nelson projects a significant change in market demand by 2025. The mix of housing stock required to meet this demand would have a blended density of approximately nine units per net acre. Given the excess of large-lot housing already on the ground relative to 2025 demand, all net new housing built between now and then would have to be attached or small-lot detached units (not including replacement of large-lot housing). The density of new and redeveloped housing would average about 13 units per net acre, 75 percent above 2003 average blended density. That is a typical density for a townhouse development. Apartments and condos boost the average, while single-family detached housing lowers it.

**Figure 1-1 Projections of Housing Demand and Density in 2025**
*Source: Nelson 2006.*

| | Density (Units per Net Acre) | 2003 Units (in 1,000s) | 2025 Units (in 1,000s) | Difference (in 1,000s) |
|---|---|---|---|---|
| Attached | 20 | 27,000 | 44,000 | 17,000 |
| Small-lot detached | 7 | 22,000 | 40,000 | 18,000 |
| Large-lot detached | 2 | 57,000 | 56,000 | -1,000 |
| Average blended density (per net acre) | | 7.6 | 9.1 | 13.3 |

The role of density, however, should not be overemphasized. As important as density is, it is no more fundamental to compact development than are the mixing of land uses, the development of strong population and employment centers, the interconnection of streets, and the design of structures and spaces at a human scale (see Figure 1-2). Images of compact development are available in *This is Smart Growth* (Smart Growth Network 2006) and *Visualizing Density* (Lincoln Institute of Land Policy 2007).

**Figure 1-2 Nature of Compact Development versus Sprawl**
*Sources: Ewing 1997; Ewing, Pendall, and Chen 2002.*

| Compact Development | Sprawl |
|---|---|
| *Medium to high densities* | *Low densities* |
| *Mixed uses* | *Single uses* |
| *Centered development* | *Strip development* |
| *Interconnected streets* | *Poorly connected streets* |
| *Pedestrian- and transit-friendly design* | *Auto-oriented design* |

## 1.3 The High Costs of Urban Sprawl and Automobile Dependence

In 1997, the *Journal of the American Planning Association* (JAPA) carried a pair of articles on the merits of urban sprawl versus compact development (Gordon and Richardson 1997; Ewing 1997). The authors debated the characteristics, causes, and costs of sprawl, and briefly discussed cures. Gordon and Richardson's lead article—titled "Are Compact Cities a Desirable Planning Goal?"—argued that U.S. real estate markets are producing what consumers want; that the social, economic, environmental, and geopolitical impacts of that development are benign; and hence that there is no need for urban planning intervention in markets. Most relevant to concerns over global climate change, the authors contended that a "global energy glut" and vehicle emission controls rendered compact development unnecessary.

Ewing's counterpoint—"Is Los Angeles–Style Sprawl Desirable?"—defined sprawl broadly as 1) leapfrog or scattered development, 2) commercial strip development, or 3) large expanses of low-density or single-use development, as in sprawling bedroom communities, and compact development as the reverse. The article argued that U.S. real estate markets have many imperfections that cause them to "fail," that the social welfare costs of such failure are enormous, and that urban planning interventions therefore are warranted. Particularly relevant to the global climate change debate is the following:

> While the best case envisioned by [Gordon and Richardson] has the real price of gasoline holding steady, it is the worst case that worries others . . . . The fact that the most recent large-scale war fought was in the Persian Gulf is itself a testament to the risk of relying on the political stability of this region for a commodity [oil] so essential to economic activity . . . . Being unregulated, carbon dioxide emissions represent a bigger threat to national welfare than do regulated emissions. There is now a near-consensus within the scientific community that carbon dioxide build-up in the atmosphere is causing global climate change, and that the long-term effects could be catastrophic.

A decade later, there seems to be little doubt that the "worst case" scenario is upon us. The urbanized area of the United States has grown almost three times faster than metropolitan population, as urban development sprawled outwards unchecked (see Figure 1-3). This development pattern has boosted VMT and reduced the amount of forest land available to absorb $CO_2$.

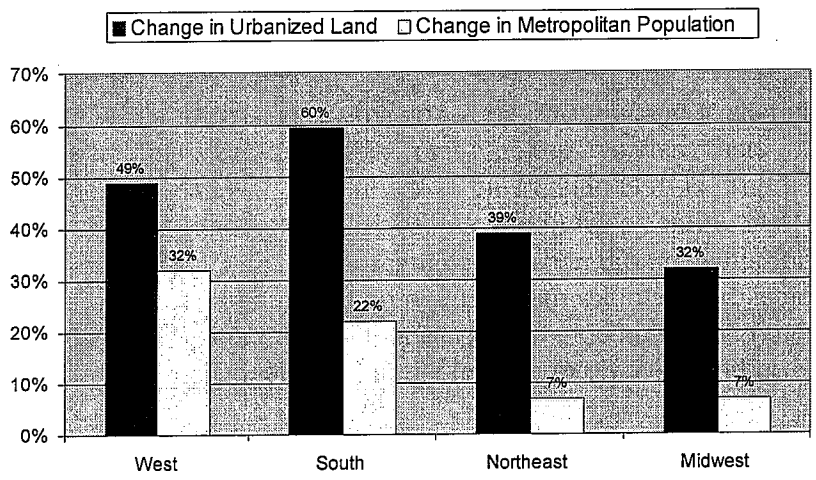
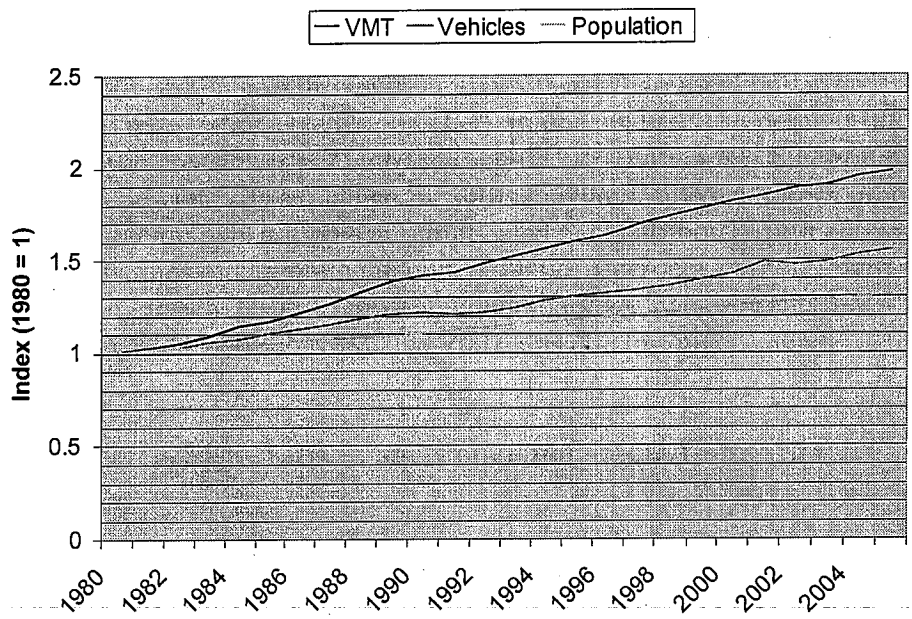


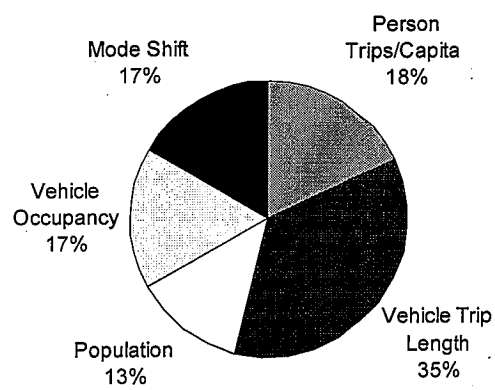

**Figure 1-3 Growth of Population and Urbanized Land Area by Census Region between 1982 and 1997**
*Source: Fulton et al. 2001.*

Vehicle miles traveled in the United States have grown three times faster than the population, and almost twice as fast as vehicle registrations (see Figure 1-4). In one analysis, 36 percent of the VMT growth was explained by increasing trip length (see Figure 1-5), which is a function of development patterns. Another 17 percent was explained by shifts to automobile trips from other modes of transportation. Again, development patterns are implicated. Yet another 17 percent was due to lower vehicle occupancy, as rates of carpooling declined. Only 13 percent of the growth in VMT was explained by population growth. Using comparable methodology, we estimate that one-third of the national growth in VMT between 1990 and 2001 was due to longer vehicle trips.[2]

**Figure 1-4 Growth of VMT, Vehicle Registrations, and Population in the United States relative to 1980 Values**
*Source: FHWA 2005.*

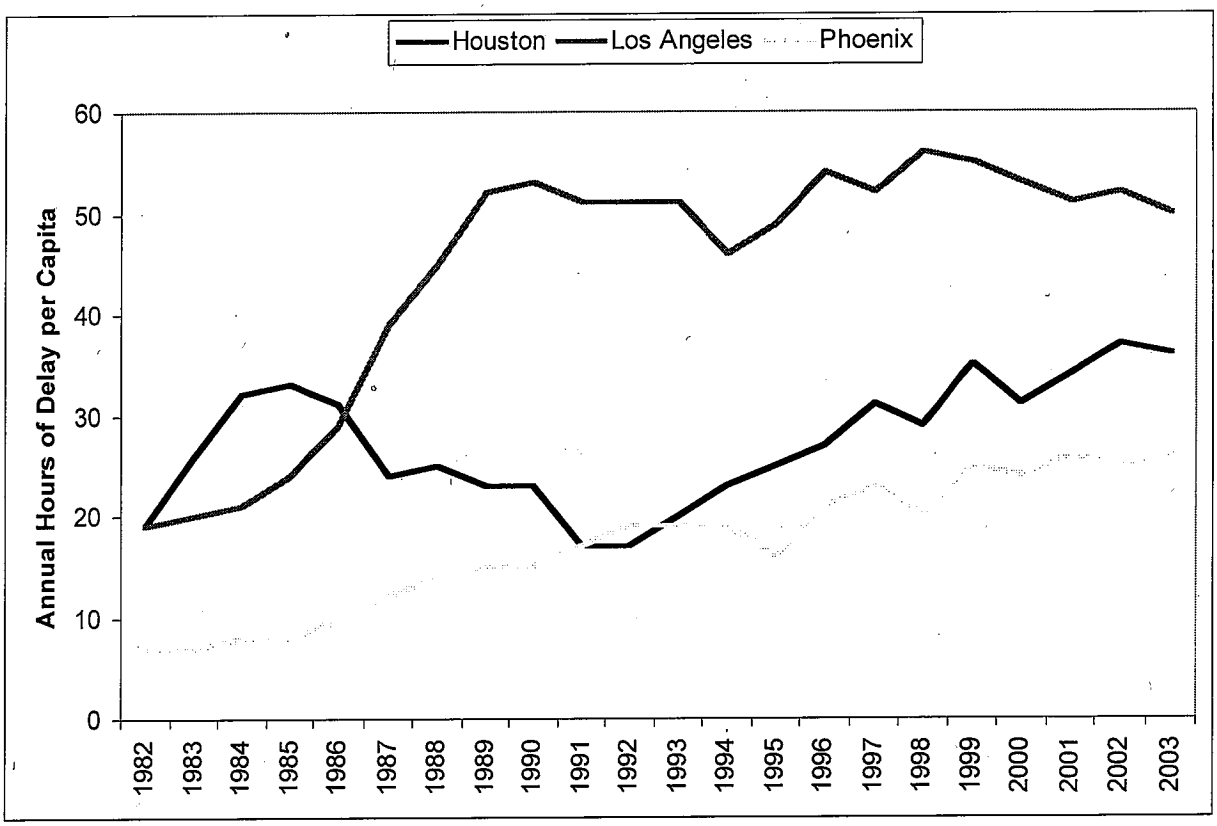



Vehicle miles traveled have grown more than twice as fast as highway capacity in urbanized areas of the United States. In all 85 urbanized areas for which statistics are available, highways became more congested between 1982 and 2003 (Schrank and Lomax 2005). This is true even in regions that struggled to pave their way out of congestion and appeared to be succeeding for a time (see Figure 1-6). Highway building itself induces more traffic and urban sprawl, in a never-ending spiral. (This will be discussed in greater detail in Chapter 5, Induced Traffic and Induced Development.)




[2] Between 1995 and 2001, total VMT in the United States increased by 34 percent, while average vehicle trip length increased by 11.5 percent (Hu and Reuscher 2004).

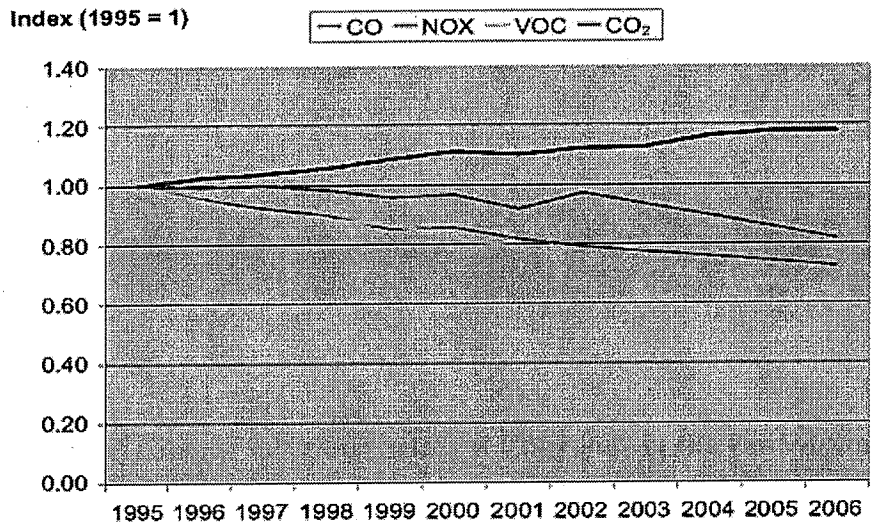
**Figure 1-6 Growth of Annual Hours of Delay per Capita**
*Source: Schrank and Lomax 2005.*




Carbon dioxide emissions from the transportation sector have grown while regulated pollutant emissions actually declined, thanks to improved fuel and engine technology (see Figure 1-7).[3] Carbon dioxide emissions are proportional to gasoline consumption and, during this period, improvements in vehicle fuel efficiency were overwhelmed by the growth in VMT. Under business-as-usual policies, VMT growth will continue to surpass technology gains. (See Chapter 2, The VMT/$CO_2$/Climate Connection, for more details.)

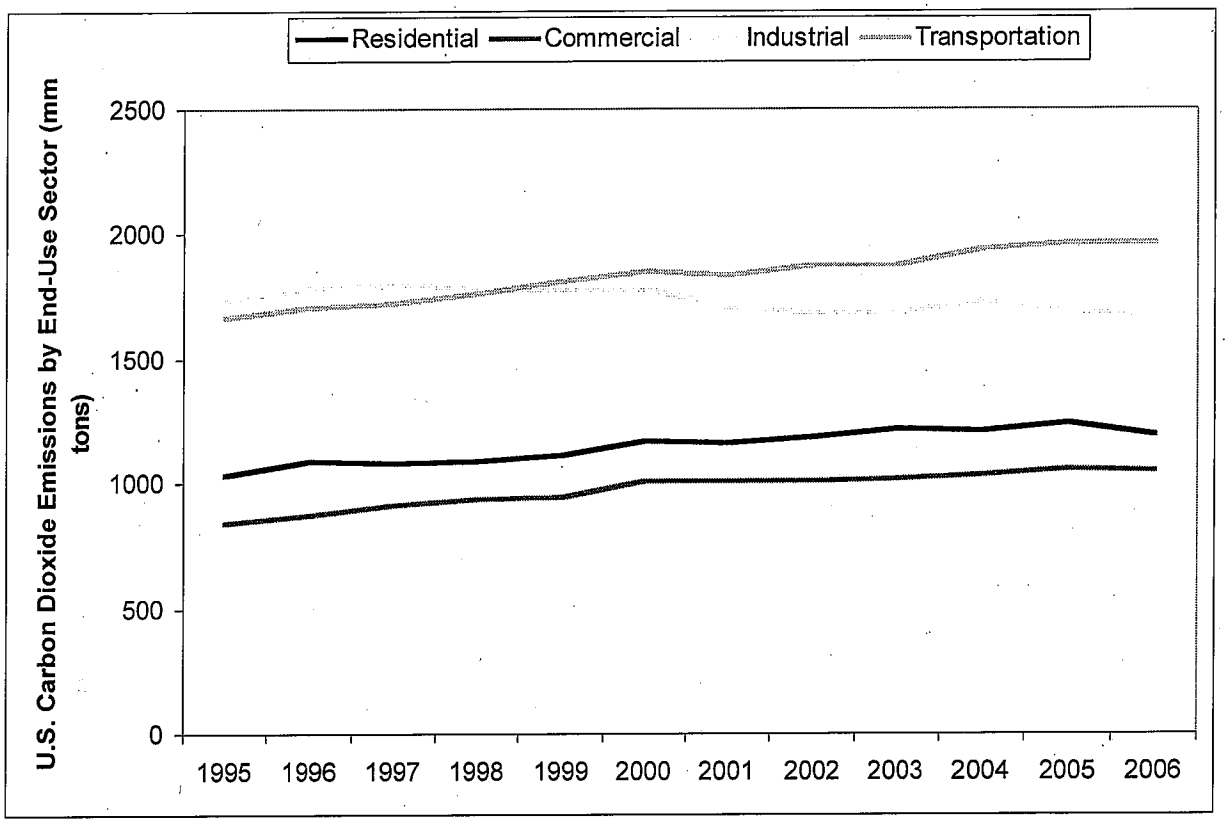
[3] The advent of "first-generation" catalytic converters in 1975 significantly reduced hydrocarbon and carbon monoxide (CO) emissions. Because lead inactivates the catalyst, 1975 also saw the widespread introduction of unleaded gasoline. The next milestone in vehicle emission control technology came in 1980 and 1981. Manufacturers equipped new cars with more sophisticated emission control systems that generally include a "three-way" catalyst (which converts CO and hydrocarbons to $CO_2$ and water, and also helps reduce nitrogen oxides to elemental nitrogen and oxygen). On-board computers and oxygen sensors help optimize the efficiency of the catalytic converters. Vehicle emissions are being further reduced under 1990 Clean Air Act amendments, which include even tighter tailpipe standards, improved control of evaporative emissions, and computerized diagnostic systems that identify malfunctioning emission controls.

**Figure 1-7 Change in Transportation Emissions in the United States Relative to 1995 Values**
*Source: EPA undated.*



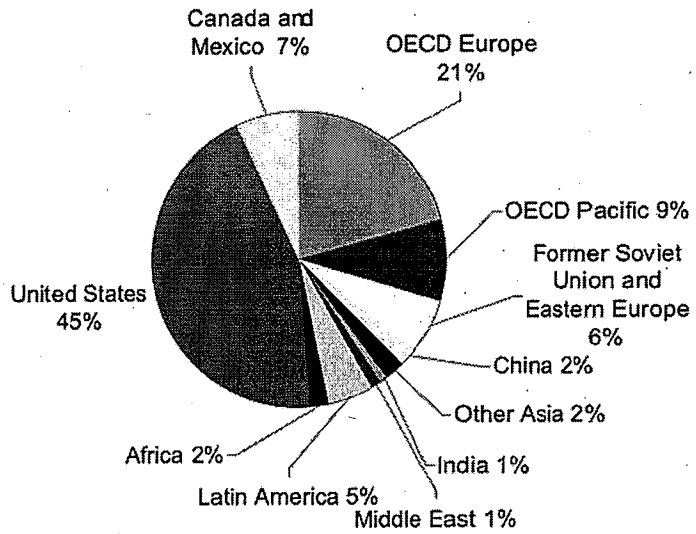

The transportation sector has become the largest source of $CO_2$ emissions in the United States, surpassing the industrial sector (see Figure 1-8). It now accounts for one-third of the U.S. total. Unless action is taken, the transportation sector's share of $CO_2$ emissions is expected to increase as VMT outpaces population growth (see Chapter 2).

**Figure 1-8 U.S. Carbon Dioxide Emissions by End-Use Sector**
*Source: EIA 2007a.*




The United States is home to only 5 percent of the world's population, but U.S. residents own almost a third of the world's cars, which account for 45 percent of the $CO_2$ emissions generated by cars worldwide (see Figure 1-9). U.S. cars play a disproportionate role in global warming because they are less fuel efficient than cars elsewhere in the world, and also because they are driven farther.

**Figure 1-9 Light-Duty Vehicle Emissions by World Region, 2003**
*Source: DiCicco and Fung 2006.*



## *1.4 A Perfect Storm in Climate Policy*

Author Sebastian Junger coined the expression "a perfect storm" to describe the confluence of different weather conditions that created a powerful 1991 storm in the Atlantic Ocean. The phrase has come to describe the simultaneous occurrence of events which, taken individually, would be far less momentous than the result of their confluence. It seems an appropriate metaphor for what currently is happening in two areas of public policy and in private real estate markets. It also is a good metaphor for what will occur in U.S. urban development generally as these three forces collide.

U.S. climate policy is one area in which a perfect storm is brewing. The issue of climate change has risen to prominence worldwide, and become compelling in the United States, in only 15 years, as the following actions indicate.

- June 1992: The United Nations Framework Convention on Climate Change (UNFCCC), opened for signatures at the "Earth Summit" in Rio de Janeiro, calls for stabilizing GHG concentrations in the atmosphere. The United States is a signatory.

- December 1997: The Kyoto Protocol to the UNFCCC establishes a set of quantified GHG emission targets for developed countries. The United States does not ratify the protocol.

- June 2002: The U.S. government acknowledges for the first time that human activity is contributing to global warming, in a report issued by the U.S. Environmental Protection Agency (EPA) that is challenged by the White House.

- June 2006: A committee convened by the National Academies of Science concludes that human activities are largely responsible for recent global warming.

- September 2006: California becomes the first state to adopt legislation—the Global Warming Solutions Act of 2006 (AB 32)—requiring regulations and market actions to reduce the state's GHG emissions to 1990 levels by 2020. Eighteen other states later adopt similar targets or mandates.

The pace has accelerated in 2007:

- January 2007: Major U.S. corporations and environmental groups, banding together as the U.S. Climate Action Partnership, call for a 10 to 30 percent reduction in $CO_2$ emissions within 30 years (USCAP 2007).

- April: The U.S. Supreme Court rules that the EPA has the authority to regulate GHG emissions, and has the duty to do so unless it can provide a scientific basis for not acting.

- May: Tulsa, Oklahoma, becomes the 500th city to sign the U.S. Mayors Climate Protection Agreement to reduce greenhouse gas emissions (U.S. Conference of Mayors 2007).

- June: In the largest international public opinion survey ever taken, most of the world identifies environmental degradation as the greatest danger—above nuclear weapons, AIDS, and ethnic hatred (Pew Research Center 2007). Global warming, in particular, is viewed as a "very serious" problem (see Figure 1-11).

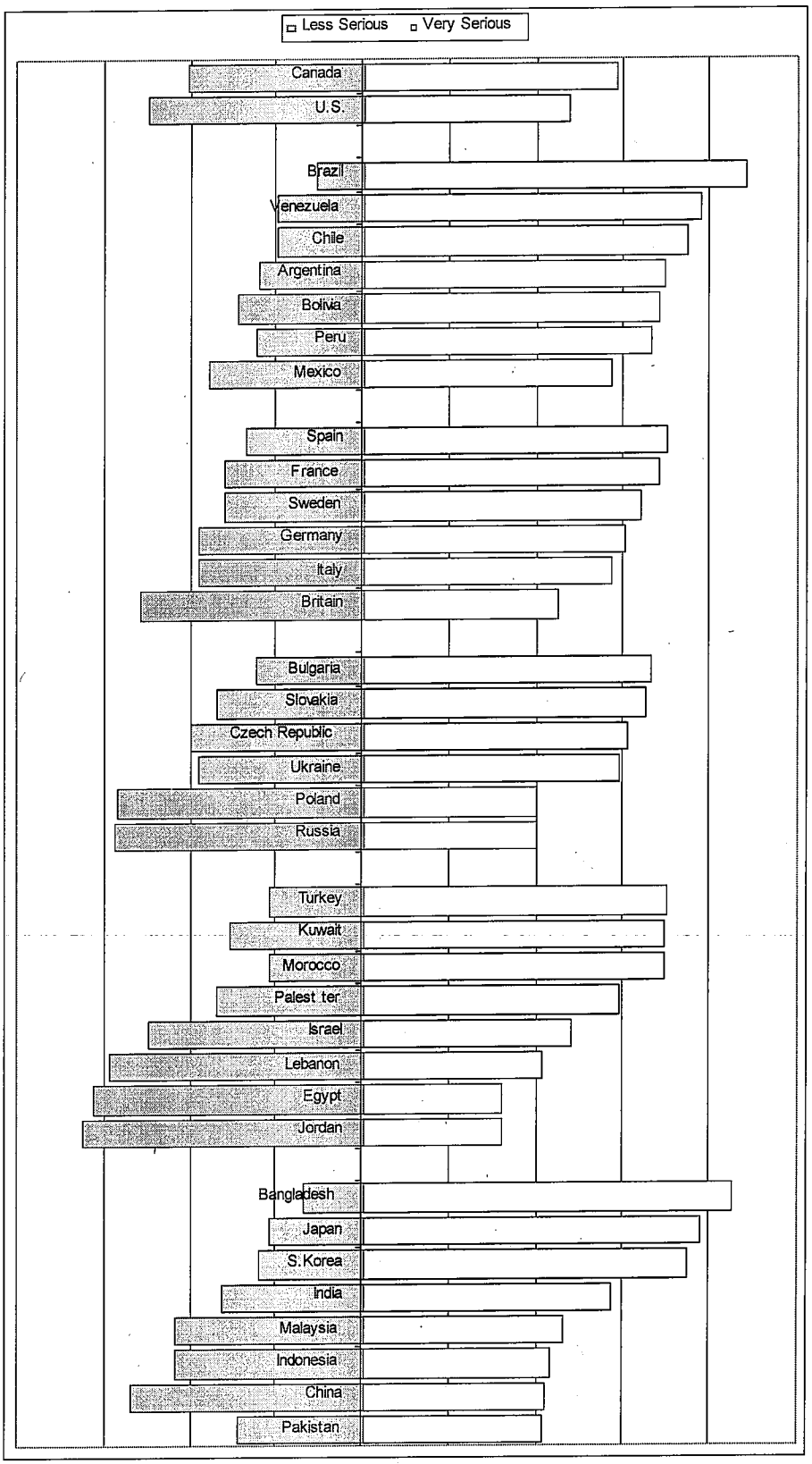
- July: Congressional lawmakers have introduced more than 125 bills, resolutions, and amendments specifically addressing global climate change and GHG emissions, compared with the 106 pieces of relevant legislation introduced during the entire two-year term of the previous Congress (Pew Center on Global Climate Change 2007).

- August: California's attorney general settles his sprawl and carbon emissions case with San Bernardino County. The county agrees to amend its general plan and create a new GHG reduction plan within 30 months to outline opportunities and strategies—especially land use decisions—to reduce GHG emissions.

- August: Russian minisubmarines plant a national flag under the North Pole, claiming the Artic seabed as Russian territory for future oil exploration and thus precipitating an Artic land grab. Arctic oil exploration will become feasible only because global warming is melting and thus shrinking the Artic icecap—and, ironically, the oil and gas extracted will only accelerate the problem as they are burned.

- September: President George W. Bush hosts a climate change summit for top officials from the world's major economies to come to agreement on a framework for lowering global GHG emissions in the post-Kyoto era.

**Figure 1-10 World Views on Global Warming: How Serious a Problem?**
Source: Pew Research Center 2007



A paradigm shift can occur very rapidly in the physical sciences, as the dominant scientific view changes in response to overwhelming evidence. The 29,000 data series drawn upon by the 2,500 top climate scientists on the U.N. Intergovernmental Panel on Climate Change (IPCC 2007b) constitute that evidentiary base.[4] Since the early 1990s, the scientific community has come to agree on the reality of climate change, on the contribution of human activity to climate change, and on the catastrophic consequences if current trends continue. Social revolutions are slower than scientific revolutions. Public opinion about global warming is changing more slowly than scientific opinion, and political action may be slower still. But they, too, are changing, irrevocably.

## 1.5 A Perfect Storm in Consumer Demand

There are many reasons why smart growth may be the "low-hanging fruit" for reducing $CO_2$ emissions in the transportation sector. The most compelling factor is the large and rising consumer demand for homes in neighborhoods that exhibit compact characteristics. The real estate analysis firm Robert Charles Lesser & Co. (RCLCO) has conducted a dozen consumer preference surveys in suburban and urban locations for a variety of builders to help them develop new projects.[5] The RCLCO surveys have found that about one-third of the respondents in every location are interested in smart growth housing products and communities (Logan 2007). Preference varies by geography, economic and demographic fundamentals, and buyer profiles; life stage and income are key variables. Other studies by the National Association of Homebuilders (NAH), the National Association of Realtors (NAR), the Fannie Mae Foundation, high-production builders, and other researchers have corroborated these results, with some estimating even greater demand for smart growth housing products (Myers and Gearin 2001).

Perhaps the best national assessment of the current demand for smart growth is the National Survey on Communities, conducted for Smart Growth America (a nonprofit advocacy group) and the NAR (Belden Russonello & Stewart 2004). In this survey, respondents were given a choice between communities labeled "A" and "B." Community A was described as having single-family homes on large lots, no sidewalks, shopping and schools located a few miles away, commutes to work of 45 minutes or more, and no public transportation. In contrast, community B was described as having a mix of single-family and other housing, sidewalks, shopping and schools within walking distance, commutes of less than 45 minutes, and nearby public transportation.

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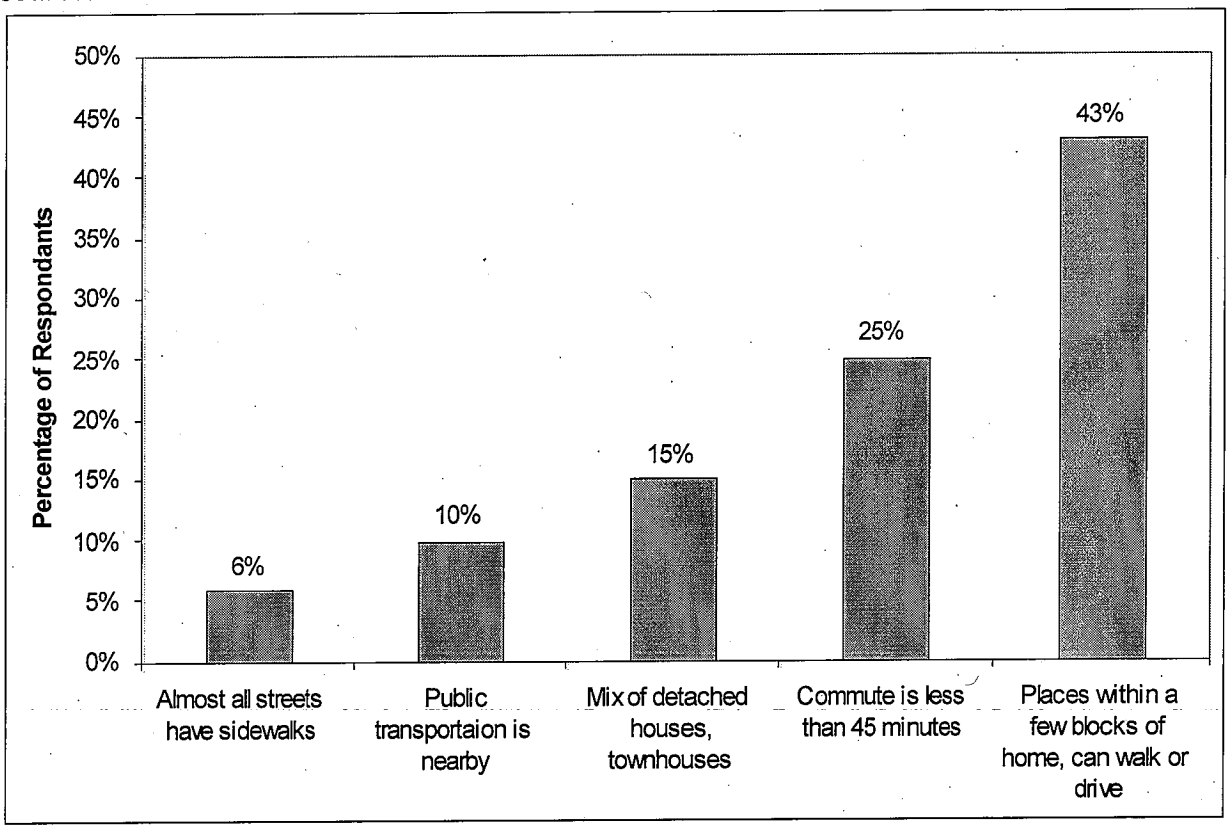
[4] The data series show significant changes in observations of physical systems (snow, ice, and frozen ground; hydrology; and coastal processes) and biological systems (terrestrial, marine, and freshwater biological systems), together with surface air temperature changes over the period 1970 to 2004. A subset of about 29,000 data series was selected from about 80,000 data series from 577 studies. These met the following criteria: 1) ending in 1990 or later; 2) spanning a period of at least 20 years; and 3) showing a significant change in either direction, as assessed in individual studies.

[5] These places include Albuquerque, Atlanta, Boise, Charlotte, Chattanooga, Denver, Orlando, Phoenix, Provo, Savannah, and Tampa.

Overall, 55 percent of Americans indicated a preference for community B, the smart growth community. Of those who said they think they will buy a house within the next three years, 61 percent are more likely to look for a home in a smart growth community than a conventional community. Commute time was a major factor in how respondents chose between A and B. It appears that about a third of the market would choose the smart growth community over the conventional community if commutes were comparable, and more than another quarter would choose the smart growth community if it were located closer to employment than the conventional alternative, thereby reducing commute time.

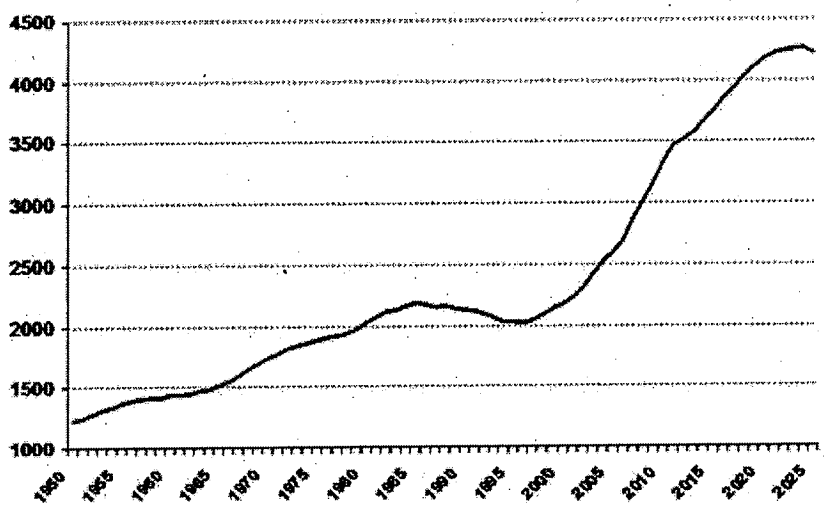
**Figure 1-11 Attractions of a Smart Growth Community***
*Source: Belden Russonello & Stewart 2004*




* For those choosing the smart growth community. The question was "Look at the community you selected and choose the ONE most appealing characteristic of that community for you."

When it comes to housing demand, demographics are destiny. As baby boomers become empty nesters and retirees, they are exhibiting a strong preference for compact, walkable neighborhoods. So are single adults and married couples without children. These trends likely will continue, because the baby boom generation represents America's largest generational cohort. By 2020, the number of individuals turning 65 years of age will skyrocket to more than 4 million per year (see Figure 1-12) Between 2007 and 2050, the share of the U.S. population older than 65 years of age will grow from 11 percent to 15.9 percent (U.S. Census Bureau 2004).

**Figure 1-12 Americans Turning 65 Years Old Annually, 1950 to 2025**
*Source: He et al. 2006*

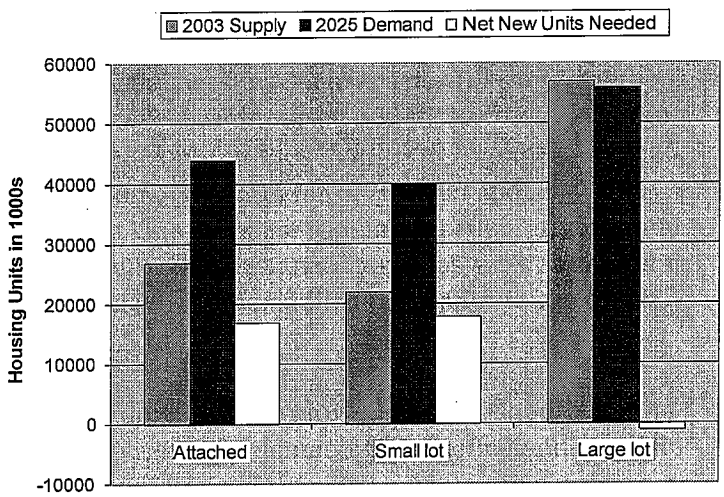



Growth in households without children (including one-person households) also will rise dramatically. From 2000 to 2025, households without children will account for 88 percent of total growth in households. (Thirty-four percent will be one-person households). By 2025, only 28 percent of households will have children (Nelson, 2006).

Some of this change in preferences also appears to be cultural, particularly among Generation Xers who are now fully engaged in the home buying market. According to research by Yankelovich, a leading marketing services consultancy, Gen Xers value traditional face-to-face relationships with neighbors and neighborhood characteristics such as sidewalks and nearby recreational facilities. Yankelovich president J. Walker Smith discussed these findings at the June 2004 NAHB conference, noting that "planned communities that foster togetherness and neighborhood life will resonate with this generation" (NAHB 2004). Another industry analyst, Brent Harrington of DMB Associates, reports that Gen Xers are looking for more diverse and compact communities characterized by smaller but better-designed homes as well as shopping and schools in more central locations, reflecting an "extreme disillusionment with the bland, vanilla suburbs" (Anderson 2004).

This means that the demand for homes located in downtown, in-town, close-in suburban, and other relatively compact locations will continue to rise. The demand for attached and small-lot housing will exceed the current supply by 35 million units (71 percent), while the demand for large-lot housing actually will be less than the current supply (see Figure 1-13).

**Figure 1-13 2003 Housing Supply versus 2025 Housing Demand**
*Source: Nelson 2006.*

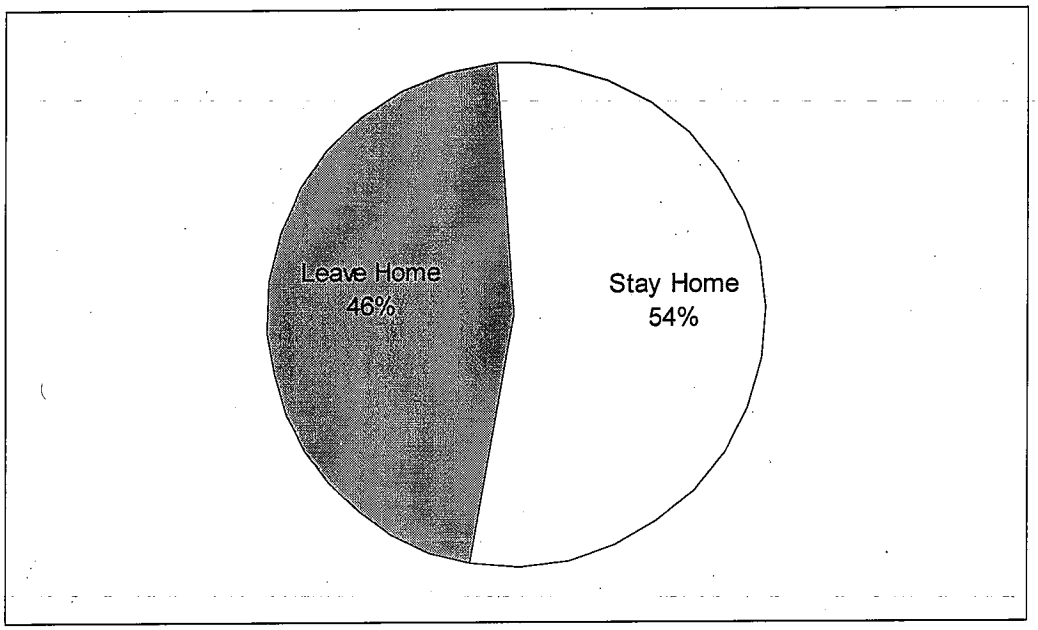



These trends are visible now: Downtown and in-town housing tops the list of hot markets each year in the Urban Land Institute's *Emerging Trends in Real Estate* (ULI 2005, 2006, 2007). In addition, new urban and smart growth communities are in such high demand that they not only

command a price premium at the point of purchase, but also hold their premium values over time (Eppli and Tu 1999, 2007; Leinberger 2007).

In addition to changing housing and neighborhood preferences, many stakeholders are carefully watching changes in travel behavior and needs, especially among older Americans. For example, the nonprofit association AARP has made transportation and quality-of-life matters one of its top policy issues to tackle in the next decade. The AARP is concerned because roughly one in five people over 65 years of age do not drive at all, and more than half drive only occasionally; that is, they do not drive on most days (STPP 2004). Older adults who lose their ability to drive tend to lose their independence unless they have other ways of accessing shopping, recreation, medical care, and other basic needs (see Figure 1-14).

**Figure 1-14 Average Daily Travel Patterns for Non-drivers over Age 65**
*Source: STPP 2004.*

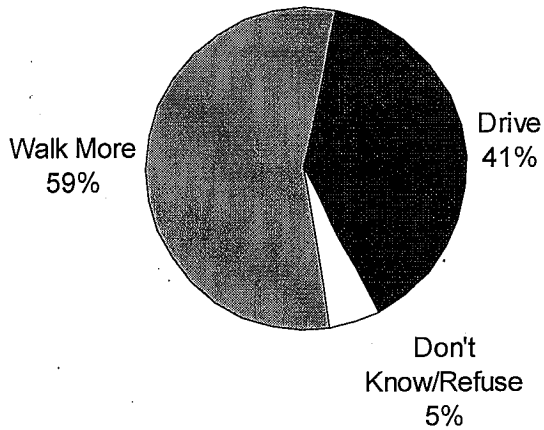



AARP surveys suggest that most people want to "age in place" (Bayer and Harper 2000; Mathew Greenwald & Associates 2003). In most areas where older Americans are aging in place, public transportation services are not available. In fact, according to a national poll, only 45 percent of Americans over 65 live within close proximity to public transportation (Mathew Greenwald & Associates 2003).

Fifty-five percent of respondents to another poll said that they would prefer to walk more throughout the day rather than drive everywhere (see Figure 1-15). The elderly are particularly inclined to walk when conditions are right (Mathew Greenwald & Associates 2003). These results, plus the high cost of special transportation services, are reasons for making sure older people can easily access transit and live in safe, walkable communities. Future community design, development, and transportation decisions will strongly influence their mobility choices.

**Figure 1-15 Americans Want to Walk More***
*Source: Belden Russonello & Stewart 2003.*

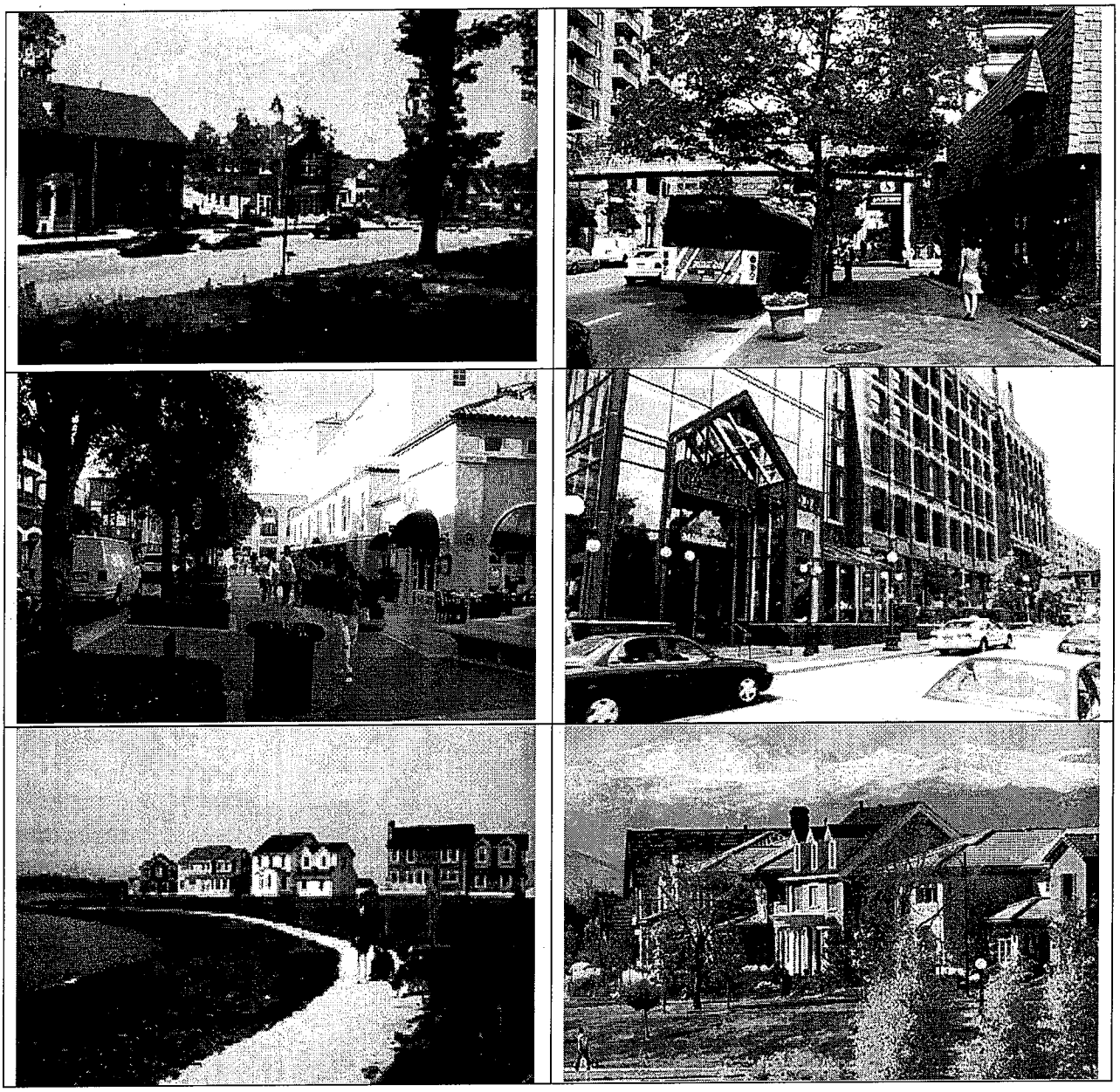
*The question was: Please tell me which of the following statements describe you more: A) If it were possible, I would like to walk more throughout the day either to get to specific places or for exercise, or B) I prefer to drive my car wherever I go?




## 1.6 And a Perfect Storm in Urban Planning

Yet another perfect storm is brewing in the land use and transportation planning fields. Although it is much less intense, this storm is swirling in the same direction as the ones in climate policy and consumer preferences. The urban planning field has been overtaken by movements promoting alternatives to conventional auto-oriented sprawl. Planners now advocate urban villages, neotraditional neighborhoods, transit-oriented developments (TODs), mixed-use activity centers, jobs/housing balance, context-sensitive highway designs, and traffic calming.

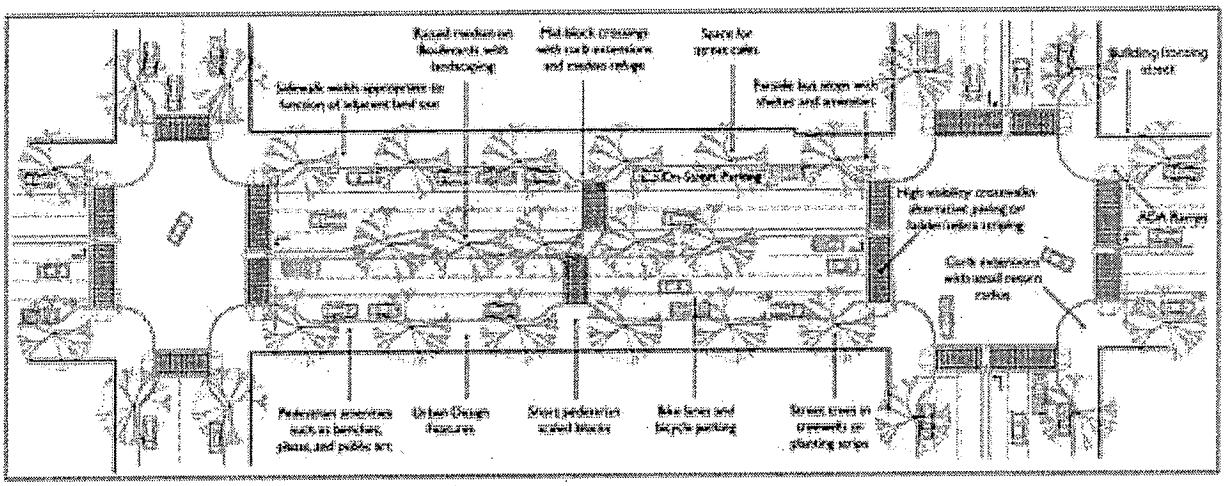
Alternative models of land development are everywhere. A 2003 listing shows 647 new urbanist developments in some state of planning or construction (New Urban News 2003), even though the new urbanist movement began only 12 years earlier. *Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects* identifies 117 TODs on the ground or substantially developed as of late 2002 (Cervero et al. 2004). The first TOD guidelines were issued about a decade earlier. In 2004, there were more than 100 lifestyle centers (open-air shopping centers fashioned after main streets) in the United States, a 35 percent increase from 2000 (Robaton 2005). The U.S. Green Building Council's new rating and certification system for green development, LEED (Leadership in Energy and Environmental Design) for Neighborhood Development, generated 370 applications from land developers, many more than expected by the program sponsors.



*This series of photographs illustrates alternative models of land development. Top left: Southern Village, a new urbanist village in North Carolina; top right: transit-oriented development in Bethesda, Maryland; middle left: CityPlace, a lifestyle center in West Palm Beach, Florida; middle right: infill/redevelopment (so-called "refill") in St. Paul, Minnesota; bottom left: green development in Prairie Crossing, Illinois; bottom right: Stapleton, a "new town in town" in Denver, Colorado.*

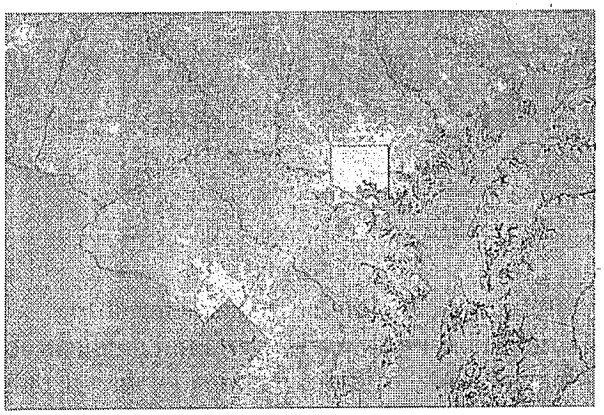
Recognizing the unsustainable growth in driving, the American Association of State Highway and Transportation Officials, representing state departments of transportation, recently called for VMT growth to be cut by half during the next 50 years (AASHTO 2007). Such unlikely allies as the Institute of Transportation Engineers and the Congress for the New Urbanism have teamed up to develop new context-sensitive street standards for walkable communities (see the illustration below). At the local level, several hundred traffic-calming programs have been created in the past decade; the term traffic calming was not even used in the United States until the mid-1990s (Ewing, Brown, and Hoyt 2005).

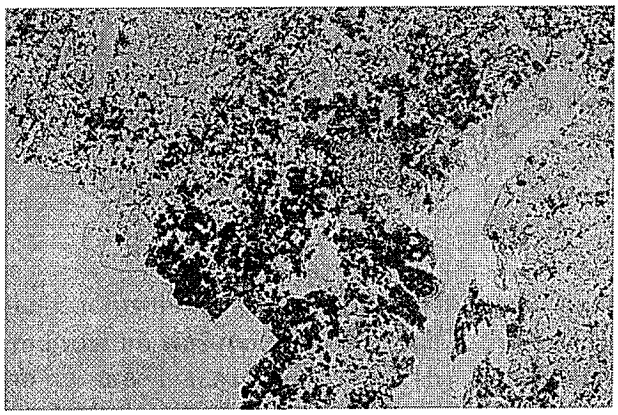
**Elements of a context-sensitive urban highway.**
*Kimley-Horn and Associates et al. 2006*



Loss of farmlands and natural areas—and the public benefits they provide—are behind a number of planning initiatives. The Maryland Smart Growth Program was motivated primarily by the rate at which the urban footprint was expanding into resource areas (see Figure 1-16). Nationally, most urbanized areas have seen their land area expand several times faster than their population (Fulton et al. 2001).

**Figure 1-16 Parcel Development in Maryland, 1900 to 1960 (left) and 1961 to 1997 (right)**





Fiscal constraints at the state and local levels are prompting governments to look for less expensive ways to meet infrastructure and service needs. Compact growth is less expensive to serve than sprawl, by an estimated 11 percent nationally for basic infrastructure (Burchell et al. 2002). The per capita costs of most services decline with density and rise as the spatial extent of urbanized land area increases (Carruthers and Ulfarsson 2003). The Envision Utah scenario planning process resulted in the selection of a compact growth plan that will save the region about $4.5 billion (17 percent) in infrastructure spending compared with a continuation of sprawling development (Envision Utah 2000). A major impetus for growth management is the desire to hold down public service costs.

The U.S. obesity epidemic and associated mortality, morbidity, and health care costs have added to the momentum for walkable communities. Circa 2000, a new collaboration between urban planning and public health advocates, began under the banner of active living. Out of this came the Active Living by Design Program of the Robert Wood Johnson Foundation, the Active Community Environments initiative of the Centers for Disease Control and Prevention (CDC), numerous Safe Routes to School programs, and dozens of Mayors' Healthy City initiatives. A recent literature review found that 17 of 20 studies, all dating from 2002 or later, had established statistically significant relationships between some aspect of the built environment and the risk of obesity (Papas et al. 2007).

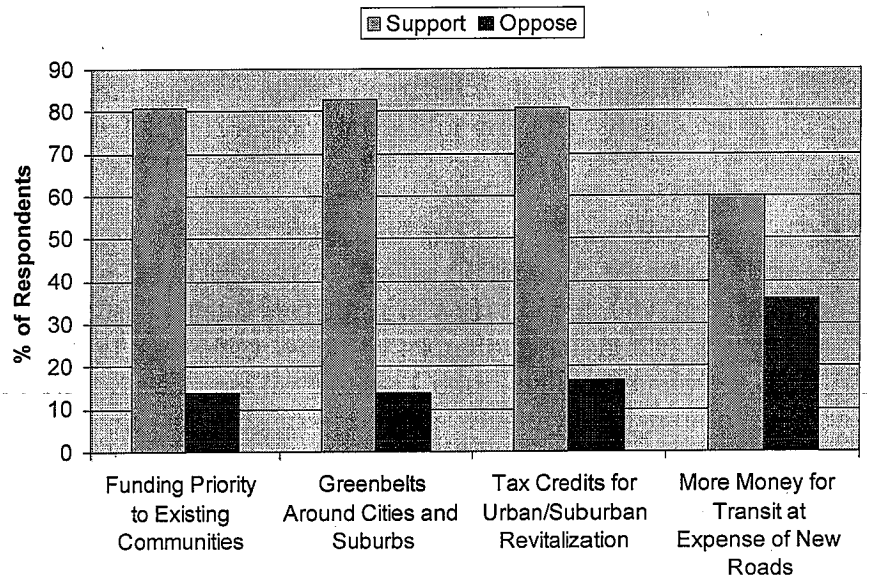
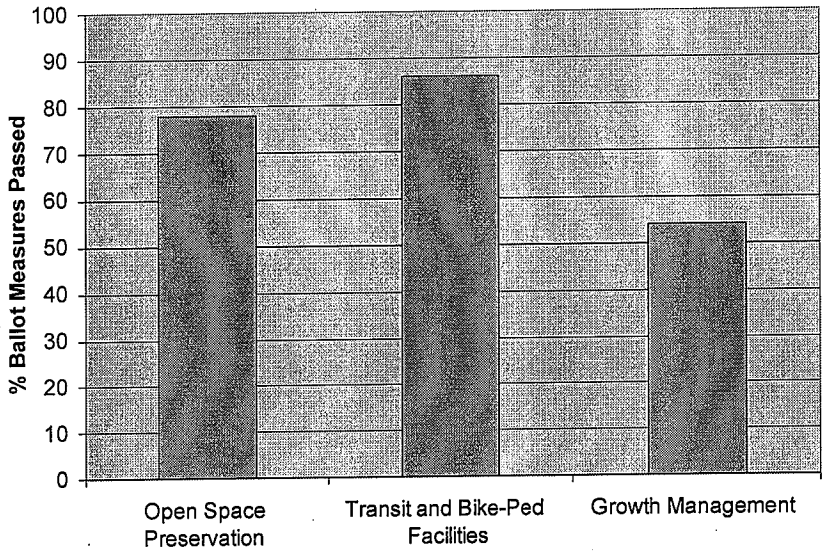



**Figure 1-17 National Opinion Poll Results**
*Source: Belden Russonello & Stewart 2000.*

Public support for smart growth policies appears to be strong and growing (Myers 1999; Myers and Puentes 2001; American Planning Association 2002; Kirby and Hollander 2005). In a 2000 national survey, a majority of respondents favored specific policies under the general heading of smart growth (see Figure 1-17). In the 2000 election, 553 state or local ballot initiatives in 38 states focused on "issues of planning or smart growth" and high percentages passed (see Figure 1-18). In 2004, voters approved 70 percent of ballot measures supporting public transit and rejected three out of four ballot initiatives on "regulatory takings" that could have significantly crimped planning efforts (Goldberg 2007).

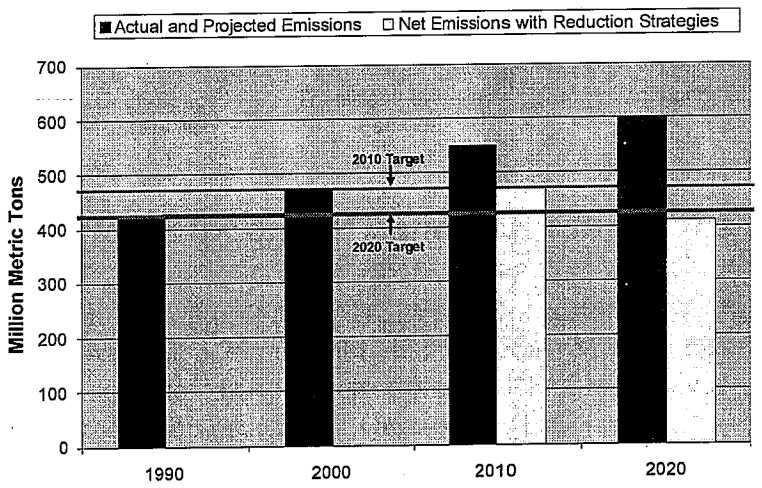
**Figure 1-18 State and Local Ballot Measures Passed, 2000 Election**
*Source: Myers and Puentes 2001.*




## 1.7 The Impact of Compact Development on VMT and $CO_2$ Emissions

California's landmark Global Warming Solutions Act of 2006 (AB 32) calls for restoring California's GHG emissions to 1990 levels by 2020, a 25 percent reduction relative to current emissions (see Figure 1-19). AB 32 also requires the Air Resources Board (ARB) to identify a list of "discrete early action greenhouse gas reduction measures." Once on the list, these measures are to be developed into regulatory proposals, adopted by the ARB, and made enforceable by January 1, 2010.

**Figure 1-19 California's Projected GHG Emissions and Targets**
*Source: Climate Action Team 2007.*




Pursuant to the act, the ARB released *Proposed Early Actions to Mitigate Climate Change in California* (ARB 2007). At the same time, the California Environmental Protection Agency's Climate Action Team recommended 21 additional actions for which GHG emission reductions have been quantified (Climate Action Team 2007). Of all the actions on the original list, those expected to achieve the second-largest reduction (originally 18 million metric tons per year $CO_2$ equivalent by 2020, since lowered to 10 million metric tons) fell under the heading of "smart land use and intelligent transportation." No details

were provided as to what this category of actions might entail, or how the targeted reduction might be achieved.
How much could a transition from sprawl to compact development reasonably reduce U.S. transport $CO_2$ levels relative to current trends? The answer is the product of the following six factors:

- market share of compact development;
- reduction in VMT per capita with compact development;
- increment of new development or redevelopment relative to the base;
- proportion of weighted VMT within urban areas;
- ratio of $CO_2$ to VMT reduction for urban travel; and
- proportion of transport $CO_2$ due to motor vehicle travel.

Each factor is discussed below and quantified in turn.

### 1.7.1 Market Share of Compact Development

The first factor that will determine $CO_2$ reduction with compact development is market penetration during the forecast period, 2007 to 2050. The market share of compact development in the United States is growing but probably still small (Sobel 2006). No comprehensive inventory exists.

Two factors, however, suggest that whatever the market share is today, it will increase dramatically during the forecast period. One factor is the current undersupply of compact development relative to demand (see section 1.5). "A review of existing studies on consumer demand for smart growth products as well as consumer surveys . . . consistently find that at least one third of the consumer real estate market prefers smart growth development" (Logan 2007). The other factor is changing demographics (also discussed in section 1.5). "The aging of the baby boomers is an inexorable force likely to increase the number of households desiring denser residential environments" (Myers and Gearin 2001). The question is, how fast will the supply of compact development respond to this demand?

Over the long run, it is reasonable to assume that what is supplied by the development industry will roughly equal what is demanded by the market, with a time lag. This will be true, provided government policies allow and encourage it. If a third of the market currently wants the density, diversity, and design of smart growth, and almost another third wants the destination accessibility of smart growth (see section 1.5), the market will be inclined to provide these product types.

Changing demographics and lifestyles will increase these proportions. The policy recommendations presented in Chapter 7 will facilitate market changes as well as make a contribution of their own to growing market shares. We will assume that between now and 2050,

the *lower bound on the proportion of compact development is six-tenths and the upper bound is nine-tenths*, consistent with demographic trends and the current undersupply. As discussed in subsection 1.7.3, this still leaves more than 40 percent of development as it is today, largely sprawling and auto oriented.

### 1.7.2 Reduction in VMT per Capita with Compact Development

Based on the urban planning literature reviewed in this publication, it appears that compact development has the potential to reduce VMT per capita by anywhere from 20 to 40 percent relative to sprawl. The actual reduction in VMT per capita will depend on two factors: how bad trend development patterns are in terms of the so-called "five Ds" (density, diversity, design, destination accessibility, and distance to transit); and how good alternative growth patterns are in terms of these same five Ds. The five Ds, which are described in Chapter 3, are qualities of the urban environment that urban planners and developers can affect, which in turn affect travel choices.

Considering all the evidence presented in Chapter 3, it is reasonable to assume an *average reduction in VMT per capita with compact development relative to sprawl of three tenths*. This fraction applies to each increment of development or redevelopment but does not affect base development.

### 1.7.3 Increment of New Development or Redevelopment Relative to the Base

The cumulative effect of compact development also depends on how much new development or redevelopment occurs relative to a region's existing development pattern. The amount of new development and redevelopment depends, in turn, on the time horizon and the area's growth rate. The longer the time horizon and the faster the rate of development or redevelopment, the greater will be the regionwide percentage change in VMT per capita.

A recent article in the *Journal of the American Planning Association* began with the following words: "More than half of the built environment of the United States we will see in 2025 did not exist in 2000, giving planners an unprecedented opportunity to reshape the landscape" (Nelson 2006). Between 2005 and 2050, the number of residential units of all types may grow from 124 million to 176 million, or a total of 52 million.[6] In addition, each decade, roughly 6 percent of the housing stock of the previous decade is replaced,[7] with about two-thirds being rebuilt on site and another third consisting of new units built elsewhere because of land use conversions (such as a strip mall replacing houses, with the displaced homes rebuilt elsewhere).[8] Counting compounding effects, perhaps 37 million homes will need to be replaced entirely through conversion processes between 2005 and 2050. The number of new plus replaced residential units

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[6] The American Housing Survey reports about 124 million residential units in 2005 while the Census reports a population of about 296 million for the same year, for a ratio of 0.42 units per capita. As household size is not projected to change substantially over the next generation, the Census projected population for 2050 is multiplied by the ratio of residential units to population in 2005 to estimate future residential demand (see http://www.census.gov/hhes/www/housing/ahs/ahs.html).

[7] The 1990 Census reports 102 million residential units while the 2000 Census reports that 96 million survived to 2000, indicating a loss rate of about 6 percent per decade (see www.census.gov).

[8] There is no consensus on the actual rate of loss of residential units through demolition and conversion to another land use. The one-third figure is conservative based on Delphi consensus of experts (see Nelson 2006).

may reach 89 million units between 2005 and 2050, or more than 70 percent of the stock that existed in 2005.

Even more dramatic is the construction of nonresidential space, largely because, on average, about 20 percent of such space turns over each decade.[9] Nonresidential space includes retail, office, industrial, government, and other structures. From 2005 to 2050, nonresidential space will expand from about 100 billion square feet[10] to about 160 billion square feet, or by 60 billion square feet.[11] However, about 130 billion square feet will be rebuilt; some structures will be rebuilt two or more times because their useful life is less than 20 years. Perhaps a total of 190 billion square feet of nonresidential space will be constructed between 2005 and 2050, or nearly twice the volume of space that existed in 2005.

The magnitude of development ahead suggests there may be unprecedented opportunities to recast the built environment in ways that reduce a variety of emissions, especially $CO_2$. Furthermore, as noted in section 1.5, a very large share of this new development will be driven by emerging market forces that desire compact development, not because it reduces $CO_2$ emissions but rather because it is responsive to changing tastes and preferences.

Much of the built environment existing in 2005 will remain, of course, including most existing residential stock, institutional buildings, and high-rise structures. Nonetheless, we may assume that easily *two-thirds of development on the ground in 2050* will be developed or redeveloped between now and then.

### 1.7.4 Proportion of Weighted VMT within Urban Areas

A shift to compact development will affect *urban* VMT, not *rural* VMT. Put another way, compact development policies will affect travel within cities, not travel between cities. Two-thirds of the total VMT in the United States currently is urban. Heavy vehicles produce about four times more $CO_2$ emissions per mile than light vehicles, and heavy vehicles represent a higher proportion of rural VMT. Weighting VMT accordingly, 62 percent of the nation's VMT is presently urban. This estimate includes cars, trucks, and buses.

The proportion of urban VMT is growing as the United States becomes ever more urbanized. Projecting current trends out to 2050, about *four-fifths of the weighted VMT in 2050 will be urban.*

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[9] The U.S. Department of Energy's Energy Information Administration conducts the Commercial Buildings Energy Consumption Survey (CBECS) about every five years. The 1992 survey reported 68 billion square feet of nonresidential space excluding industrial space. The 1999 survey (the most compatible in format) reported 58 billion nonresident square feet existing in 1992 surviving to 1999, or an imputed loss rate of slightly more than 20 percent per decade (see http://www.eia.doe.gov/emeu/cbecs/).

[10] This figure includes industrial space (see Nelson 2006).

[11] This figure assumes about 580 square feet of space per full- and part-time worker. It is the quotient of total nonresidential space (see Nelson 2006) and workers. The U.S. Department of Commerce's Bureau of Economic Analysis reported there were 173 million total full- and part-time workers in 2005 (see www.bea.gov.) In contrast, the CBECS for 2003 estimates 1,000 square feet per full time worker. The more conservative figure is used.

### 1.7.5 Ratio of $CO_2$ to VMT Reduction

Compact development may not reduce $CO_2$ emissions by exactly the same proportion as VMT. The reasons, discussed in Chapter 2, are the $CO_2$ penalties associated with cold starts and lower operating speeds in compact areas. For the project-level simulations presented in section 3.4, the ratio of $CO_2$ to VMT reduction for compact development projects is around 0.95.

The material presented in section 2.3.3 indicates that a reduction in VMT of 30 percent would be expected to produce a reduction in $CO_2$ of about 28 percent. This figure factors in $CO_2$ penalties associated with cold starts and reduced vehicle operating speeds. Thus the ratio of $CO_2$ to VMT reduction would be around 0.93.

Given these three pieces of evidence, and weighting the second most heavily, we will conservatively assume a *$CO_2$ reduction equal to nine-tenths of the VMT reduction.*

### 1.7.6 Proportion of Transportation $CO_2$ from Motor Vehicles

Motor vehicles (automobiles, light- and heavy-duty trucks, and buses) contributed 79 percent of transportation $CO_2$ emissions in 2005 (EPA 2007, Table 3-7). This percentage is increasing over time, largely because of the growth of heavy-vehicle traffic. We will assume that *motor vehicles contribute four-fifths of transportation $CO_2$ emissions*, with the balance coming from aircraft, ships, and trains.

### 1.7.7 Net $CO_2$ Reduction in Comparison to Other Actions

Projecting out to 2050, the net $CO_2$ reduction is estimated to be as follows:

*6/10 to 9/10 (market share of compact development)*
x
*3/10 (reduction in VMT per capita with compact development)*
x
*2/3 (increment of new development or redevelopment relative to base)*
x
*4/5 (proportion of weighted VMT within urban areas)*
x
*9/10 (ratio of $CO_2$ to VMT reduction)*
x
4/5 (*proportion of transportation $CO_2$ from motor vehicles).*

Doing the math, compact development has the potential to reduce U.S. transportation $CO_2$ emissions by 7 to 10 percent, when compared to continuing urban sprawl.

A 7 to 10 percent reduction in $CO_2$ emissions should be put into perspective. The long-term elasticity of VMT with respect to fuel price is around –0.3 (see review by Victoria Transport Policy Institute 2007). The price of gasoline would have to double to produce an equivalent (30 percent) reduction in VMT. If one-quarter of the projected gasoline use were replaced with petroleum diesel, biodiesel, or electricity (a replacement rate viewed as "reasonable" within a 25-year time frame), transportation $CO_2$ emissions would decline by an estimated 8 to 11 percent (Pickrell 2003). This does not include an adjustment for $CO_2$ from sources other than motor

vehicles. The $CO_2$ savings through 2030 would be at least as large as a 31-mile-per-gallon (mpg) corporate average fuel economy (CAFE) standard (2020 combined mpg for cars and light trucks), or one-third of the savings expected from the Senate's 35-mpg CAFE standard.

The 7 to 10 percent reduction is an end-year estimate. During the 43-year period, the cumulative drop in $CO_2$ emissions would be about half this amount. Yet, the very phenomenon that limits the short- and medium-term impacts of compact development—the long-lived nature of buildings and infrastructure—makes the reduction essentially permanent and compoundable. The next 50 years of compact development would build on the base reduction from the first 50 years, and so on into the future. More immediate strategies, such as gas tax increases, do not have the same degree of permanence.

The 7 to 10 percent reduction only relates to the transportation sector. Compact development, however, would reduce $CO_2$ emissions for other sectors as well. An order-of-magnitude estimate for the residential sector is provided in Chapter 6. Controlling for socioeconomic and climatic variables, an equivalent household uses 20 percent less primary energy for space heating and cooling in a compact area than in a sprawling one. This savings is primarily due to less exterior wall area in attached and multifamily housing, and less floor area consumed at higher densities.

The 7 to 10 percent reduction does not consider the impact of intelligent transportation systems, congestion pricing, pay-as-you-drive insurance, or other complementary strategies. These might be used to better manage existing roads and public transportation, supporting smart growth or, alternatively, could be used to accelerate highway capacity expansion, undermining the smart growth impacts documented in this publication.

## 1.8 The Organization of this Book

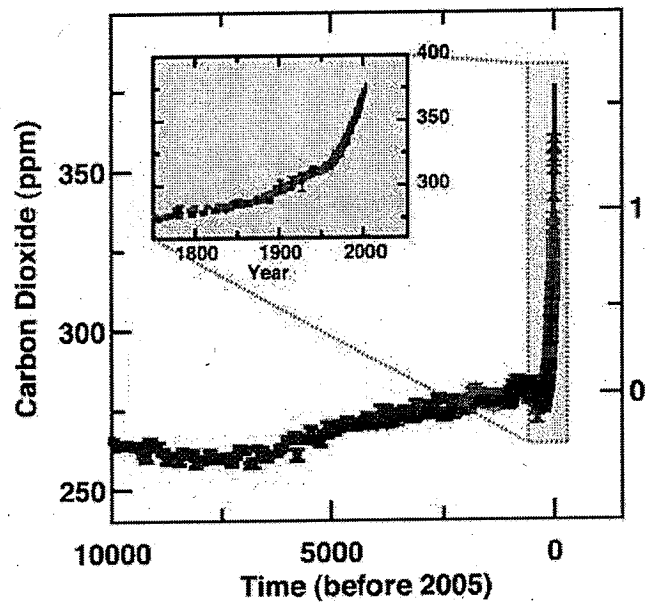
Chapter by chapter, this book addresses the impacts of the following:

- vehicular travel on greenhouse gas emissions;
- urban development on vehicular travel;
- residential preferences on urban development and travel;
- highway building on urban development and travel;
- urban development on residential energy use; and, finally,
- policy options for encouraging compact development and reducing vehicular travel.

## 2. The VMT/$CO_2$/Climate Connection

There is now a scientific consensus that greenhouse gas accumulations due to human activities are contributing to global climate change (Greenough et al. 2001; Barnett and Adger 2003; Hegerl et al. 2007; IPCC 2007a). The Fourth Assessment Report of the U.N. Intergovernmental Panel on Climate Change (IPCC 2007a, p. 2) concludes that: "Global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now far exceed preindustrial values determined from ice cores spanning many thousands of years." Greenhouse gas concentrations have risen from preindustrial levels of approximately 280 parts per million (ppm) $CO_2$ equivalent ($CO_2e$) to 430 ppm $CO_2e$ (Stern 2006).[12]

**Figure 2-1 Atmospheric Concentration of Carbon Dioxide ($CO_2$) over the Last 10,000 Years**
*Source: IPCC 2007a, p. 3.*




The result is climate change. "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global mean sea level" (IPCC 2007a, p. 5). Eleven of the last 12 years are among the 12 warmest globally since the instrumental record began in 1850 (IPCC 2007a, p. 5).[13] Long-term changes have been observed in Arctic temperatures and ice formations, ocean salinity, droughts, heavy precipitation, heat waves, and tropical cyclone intensity.

With current trends, the atmospheric concentration of $CO_2e$ is expected to rise from 430 ppm to 630 ppm by 2050. Even if GHG emissions were held at year 2000 levels, the planet would warm by 1°C over the next 100 years. Under a variety of scenarios with differing assumptions about growth, technology, and climate feedback, the likely range of warming by 2100 is between 1.1°C and 6.4°C, with a best estimate of 1.8°C to 4.0°C (IPCC 2007a, p. 12).

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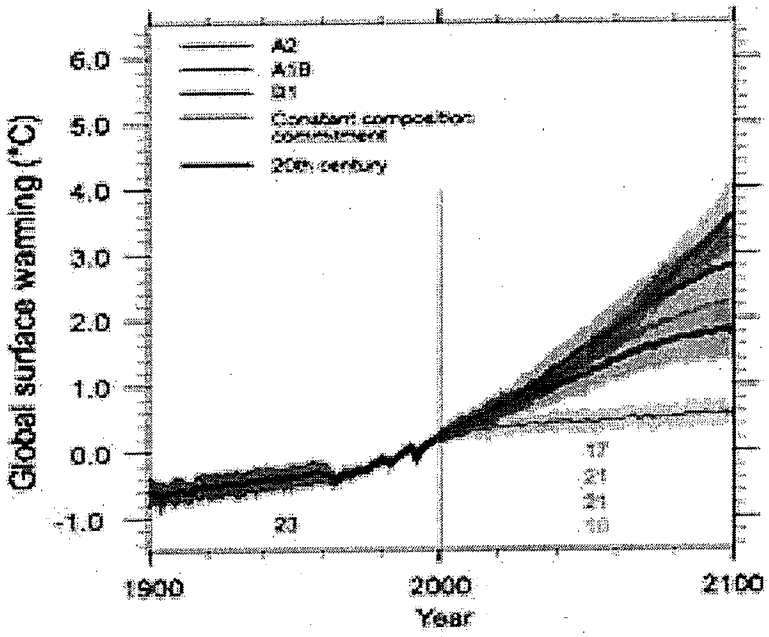
[12] Carbon dioxide equivalent ($CO_2e$) is an internationally accepted measure of the amount of global warming of greenhouse gases (GHGs) in terms of the amount of carbon dioxide ($CO_2$) that would have the same global warming potential.

[13] NASA's Goddard Institute for Space Studies identifies the five warmest years for global temperatures as (in descending order): 2005, 1998, 2002, 2003, and 2006 (Goddard 2007). Five of the last nine years have been the warmest on record in the United States (in descending order: 1998, 2006, 1999, 2001, 2005) (National Climate Data Center 2007).

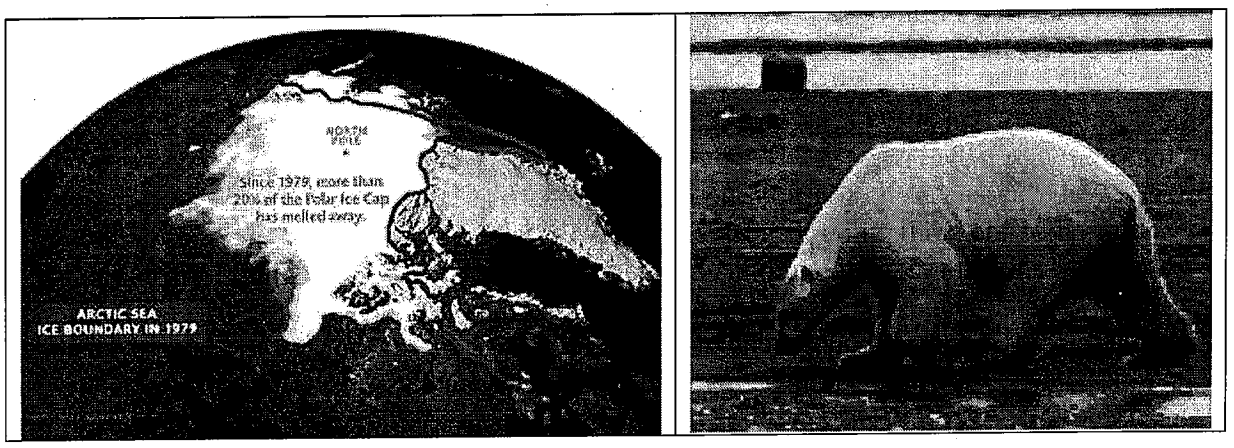
**Figure 2-2 Global Average Surface Temperature Warming under Different Scenarios**
*Source: IPCC 2007a, p. 14.*




International and domestic climate policy discussions have gravitated toward the goal of limiting the temperature increase to 2°C to 3°C (European Commission 2007). Stabilization at 450 ppm $CO_2e$ is expected to produce a 50/50 chance of keeping warming to + 2°C above preindustrial levels, whereas 550 ppm would result in a 50/50 chance of keeping warming to +3°C (Meinshausen 2006).

With a 2°C increase in global average temperature, all coral reefs are at risk of being bleached. At 3°C, more than one-third of all species will be at risk of eventual extinction. With an increase of 2°C to 3°C, coastal flooding threatens to harm or displace 70 million to 250 million people, respectively, and hundreds of millions of people face an increased risk of hunger. In this same range of temperature increase, the Amazon rainforest and Great Lakes ecosystems are at risk of collapse (Meinshausen 2006). From 1°C to 4°C, a partial deglaciation of the Greenland Ice Sheet will occur, with the sea level destined to increase by four to six meters over centuries to millennia (IPCC 2007b, p. 17; DEFRA 2006).

**A shrinking Arctic icecap threatens many species, including the polar bear.**
*NRDC undated*



Stabilization at 450 ppm $CO_2e$ would require global GHG emissions to peak around 2015 and be reduced 30 to 40 percent below 1990 levels by 2050 (Höhne, Phylipsen, and Moltmann 2007; Meinshausen and den Elzen 2005). The British government's review and the IPCC report show that the less we limit GHG emissions globally in the near term, the harder it will be to stabilize them at the target concentrations later (HM Treasury 2006; IPCC 2007c, p.15). For each five years that the peak in global emissions is delayed beyond 2015, the annual rate by which emissions must decline will increase by an additional 1 percent (Meinshausen and den Elzen 2005). One percent per year is a substantial level of effort, comparable to the reduction the United Kingdom achieved nationally after it switched all of its coal-fired power plants to natural gas in the 1990s (Helme and Schmidt 2007).

Determining the necessary GHG reductions in the United States to meet global targets requires assessment of and assumptions about expected GHG reductions in other countries. The emerging consensus is that industrialized countries will need to reduce their GHG emissions by 60 to 80 percent below 1990 levels by 2050 (European Commission 2007; Helme and Schmidt 2007; Höhne, Phylipsen, and Moltmann 2007; Meinshausen and den Elzen 2005; New England Governors/Eastern Canadian Premiers 2001; Schwarzenegger 2005). To meet this long-term goal, industrialized countries must reduce GHG emissions 15 to 30 percent below 1990 levels by 2020 (European Commission 2007; Höhne, Phylipsen, and Moltmann 2007; Meinshausen and den Elzen 2005). In August 2007, industrial nations agreed to GHG cuts 25 to 40 percent below 1990 levels by 2020 as a nonbinding starting point for a new round of international climate negotiations (Reuters 2007).

## 2.1 Prospects for the U.S. Transportation Sector

The transportation sector is responsible for 33 percent of U.S. $CO_2$ emissions (28 percent of U.S. GHG emissions), and its emissions are projected to grow faster than the average rate for all sectors of the economy (EIA 2007, Table A18). Passenger vehicles (cars and light trucks) are responsible for more than three-fifths of transportation sector $CO_2$ emissions.

The GHG reduction "required" from U.S. transportation is a function of the level of reductions that can be expected in other sectors of the economy to meet the 60 to 80 percent reduction target. While certain sectors of the economy may be able to reduce GHG emissions more than others, it is unlikely that they will be able to sufficiently overcompensate for limited progress in the transportation sector. As discussed below, current policy proposals on vehicle technology and fuels would leave passenger vehicle $CO_2$ emissions well above 1990 levels in 2030, significantly off course for meeting the 2050 target. Reduction in travel demand will be an important element of effective climate policy.

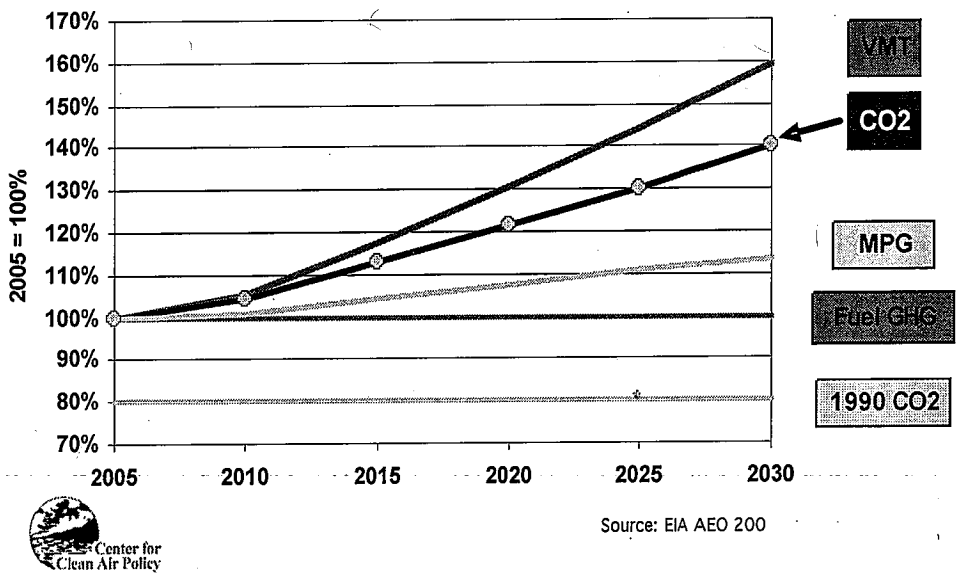
There is a popularly held expectation that electricity or hydrogen fuels will provide long-term solutions to energy security and transportation GHG concerns, essentially shifting transportation GHG emissions upstream to other sectors of the economy. Biofuels also could potentially play an important role, but their use will be limited because of land use constraints, high costs, and ecological and social concerns. A shift to electric or hydrogen cars could certainly reduce petroleum use if major technological breakthroughs and cost reductions are achieved on battery and fuel cell technologies. (Plug-in hybrid vehicles currently carry a cost premium on the order of $10,000, and the cost premium for hydrogen fuel cell vehicles is on the order of $500,000 to $1 million.)

Achieving significant GHG reductions also will require significant investments and political will. Since electricity and hydrogen are energy carriers, they result in GHG savings only if their production and transportation processes are relatively more carbon efficient than the current approach. Thus, for electricity or hydrogen to result in GHG reductions, they must be generated via low-emitting processes. Three primary energy sources could generate low-GHG electricity or hydrogen. First, renewable sources such as solar, biomass, and wind have significant but limited potential. Although these sources could potentially provide a large amount of energy, issues such as intermittent generation and local resource availability present difficulties. Second, nuclear power has great potential as a low-GHG energy source, but faces significant cost and political barriers. Third, carbon capture and sequestration (CCS)—in which $CO_2$ is removed from a coal (or other) power plant smokestack and injected underground into geological formations such as oil fields, gas fields, or saline formations—offers the possibility of continued use of coal resources with a much improved GHG profile. There is active research on CCS to assess costs, permanence, and storage capacity. Each of these three low-GHG energy sources holds significant promise but can offer no guarantees.

## 2.2 VMT and $CO_2$ Projections

The U.S. Department of Energy's Energy Information Administration (EIA) forecasts VMT to increase by 59 percent from 2005 to 2030 (the red line in Figure 2-3), outpacing projected population growth of 23 percent (EIA 2007, Table A7). The projected VMT increase represents a slowdown relative to historic VMT growth rates, but is within the likely range for future VMT growth (Polzin 2006). Over this time period, the EIA projects fuel economy for new passenger vehicles to increase by 16 percent (from 25 to 29 mpg) and the fuel economy of the full stock of vehicles (the green line in Figure 2-3) to increase by 13.3 percent as more efficient vehicles penetrate the fleet. $CO_2$ emissions would increase by 40 percent[14] over the same time frame (the dark blue line in Figure 2-3). In this case, transportation $CO_2$ emissions in 2030 would be 75 percent above 1990 levels (the turquoise line in Figure 2-3).

**Figure 2-3 Projected Growth in $CO_2$ Emissions from Cars and Light Trucks**
*Source: EIA 2007.*




U.S. fuel economy has been flat for almost 15 years, as the upward spiral of car weight and power has offset more efficient technology (Schipper 2007). In June 2007, the U.S. Senate passed new CAFE standards that would increase new passenger vehicle fuel economy (cars and light trucks combined) to 35 mpg by 2020 (U.S. Congress 2007). The state of California is implementing a low carbon standard for transportation fuels that calls for a 10 percent reduction in fuel carbon intensity by 2020 (Schwarzenegger 2007). If California's low carbon fuel standard were applied at the national level (the purple line in Figure 2-4), in conjunction with the Senate's CAFE standard of 35 mpg by 2020 (the green line in Figure 2-4), passenger vehicle $CO_2$ emissions in 2030 would be 12 percent above 2005 levels, or 40 percent above 1990 levels. In other words, projected growth of VMT would still overwhelm the $CO_2$ savings from vehicle and fuel regulations.[15]

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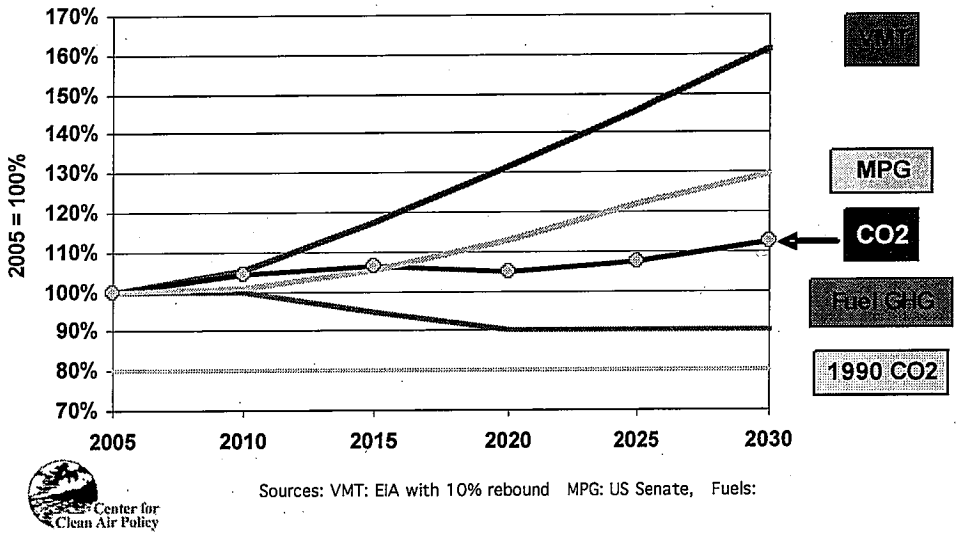
[14] 159% [vehicle miles traveled] / 1.133 [mpg] = 140% [$CO_2$ ] with constant fuel carbon content.

[15] In this scenario, VMT growth increases by 2 percentage points (61 percent growth by 2030) due to the "rebound effect" whereby driving increases as fuel economy increases (10 percent short-run elasticity).

**Figure 2-4 Projected Growth in $CO_2$ Emissions from Cars and Light Trucks, Assuming Stringent Nationwide Vehicle and Fuel Standards***
*Sources: EIA 2007; U.S. Congress 2007; Schwarzenegger 2007.*

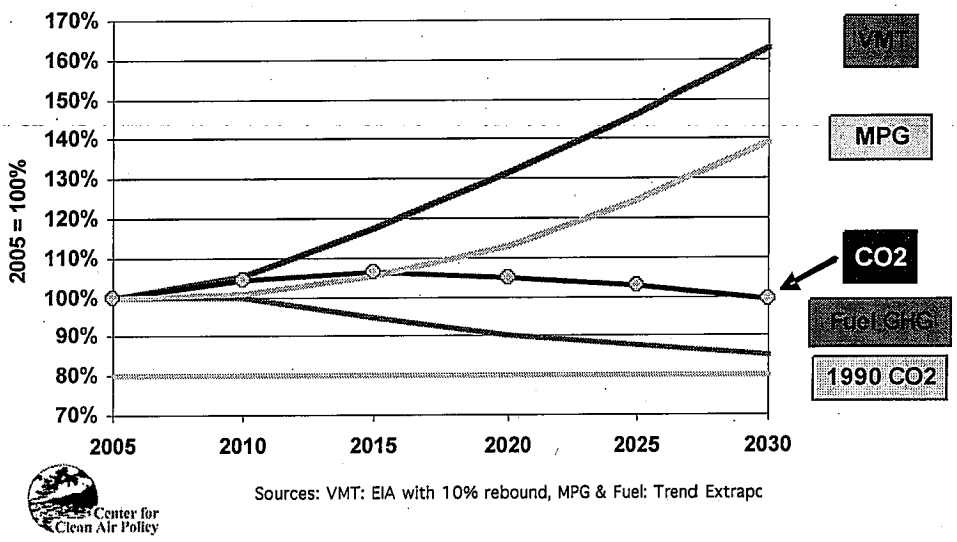
* With Senate new passenger vehicle fuel economy of 35 mpg and California low carbon fuel standard of –10 percent in 2020, applied nationally. Assumes a 10 percent rebound.




If the fuel economy and fuel carbon content trends represented in Figure 2-4 were extended through to 2030, so that new vehicle fuel economy would increase to 45 mpg and fuel carbon content would decrease to 15 percent below current levels, then 2030 $CO_2$ emissions would be reduced to 1 percent below 2005 levels, or 24 percent above 1990 levels (Figure 2-5).

**Figure 2-5 Projected Growth in CO2 Emissions from Cars and Light Trucks, Assuming Even More Stringent Nationwide Vehicle and Fuel Standards***
*Sources: EIA 2007; U.S. Congress 2007; Schwarzenegger 2007.*

*Extrapolating trends from Figure 2-4 with new passenger vehicle fuel economy of 45 mpg in 2030 and low carbon fuel standard of –15 percent in 2030.




Clearly, lowering transportation $CO_2$ emissions to 60 to 80 percent below 1990 levels by 2050 would require even greater improvements in vehicles, fuels and, almost certainly, reductions in VMT per capita.

## 2.3 Other Influences on $CO_2$ Emissions

Carbon dioxide emissions are a function not only of VMT but also of numbers of vehicle trips (VT) and vehicle operating speeds. The number of vehicle trips is directly related to the number of vehicle starts, while average vehicle operating speed is a proxy for the entire driving cycle (starts, acceleration, cruising speed, deceleration, and stops). Both affect vehicle operating efficiency and $CO_2$ emissions per vehicle mile.

### 2.3.1 Vehicle Trip Frequencies

Starting a vehicle when it is cold uses more energy and emits more $CO_2$ than does starting the vehicle after it has warmed up. For an average car in California, the California Air Resources Board EMFAC model shows cold start emissions of 213 grams $CO_2$ after a 12-hour soak.[16] To put this in context, an average passenger car emits 386 grams of $CO_2$ per mile when traveling at an average speed of 30 miles per hour.[17]

Still, any cold start penalty associated with compact development is likely to be small. From the EMFAC model, $CO_2$ emissions from *all* vehicle starts (cold, intermediate, and hot) account for just 3.3 percent of total annual passenger vehicle $CO_2$ emissions in California.[18] Moreover, while there has been some speculation in the literature that compact development could increase trip frequencies, the weight of evidence suggests otherwise. Overall trip rates appear to depend largely on household socioeconomics and demographics. Controlling for these influences, vehicle trip rates are lower in compact areas because some of a household's daily trips shift from the automobile to other modes (Ewing, DeAnna, and Li 1996; Ewing and Cervero 2001).

### 2.3.2 Vehicle Operating Speeds

Compact development policies could have secondary effects on $CO_2$ emissions by lowering (or raising) average vehicle speeds. Motor vehicles with internal combustion engines are most efficient at an average speed of about 45 miles per hour, with lower efficiency and higher $CO_2$ emission rates for speeds above and below this "sweet spot" (see Figure 2-6). The data in Figure 2-6 come from the California Air Resources Board EMFAC model and represent average speed for vehicle trips that have been calibrated to reflect real-world driving behavior, including acceleration, starts, idling, and so forth.

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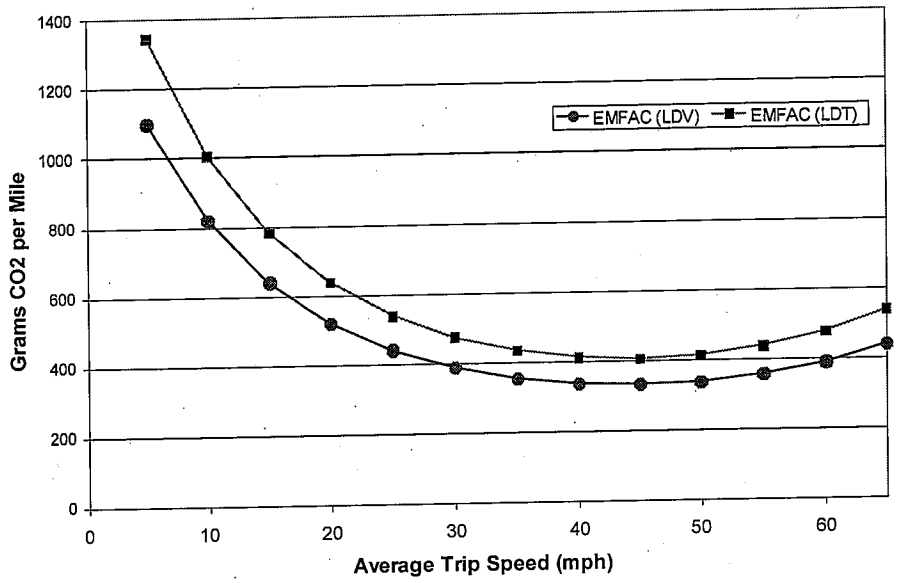
[16] Authors' calculations based on data from EMFAC 2007, V2.3 Nov. 1, 2006, provided by Jeff Long, California Air Resources Board, July 24, 2007.

[17] Authors' calculations based on data from EMFAC 2007, V2.3 Nov. 1, 2006, provided by Jeff Long, California Air Resources Board, April 25, 2007.

[18] Authors' calculations based on data from EMFAC 2007, V2.3 Nov. 1, 2006, provided by Jeff Long, California Air Resources Board, July 9, 2007.

**Figure 2-6 $CO_2$ Emission Rate versus Average Vehicle Speed***
*Source: Jeff Long, California Air Resources Board*




*Data from EMFAC 2007, V2.3 Nov. 1, 2006, provided by Jeff Long, California Air Resources Board, April 2007. Data include all model years in the range 1965 to 2007. The magnitude of the curve (not the shape) is a function of temperature and humidity assumptions, in this case 80°F and relative humidity of 50 percent.

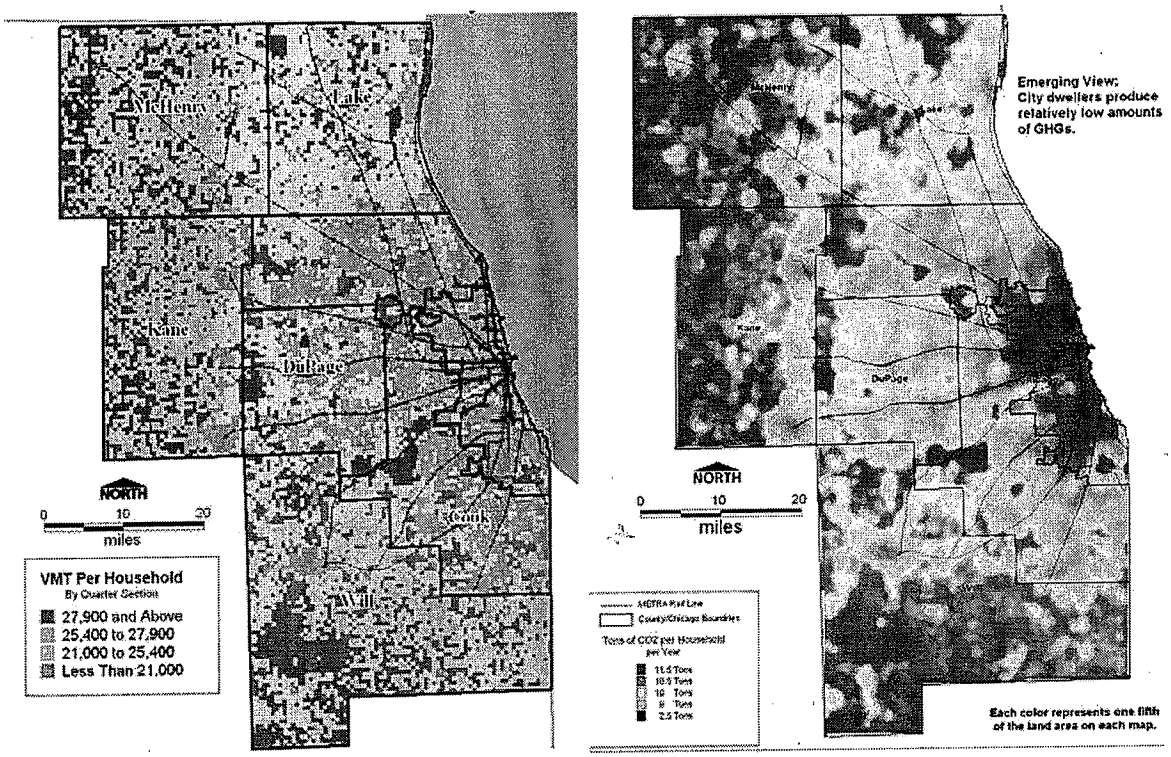
Can we therefore conclude that it would be most efficient to design cities and roadways to maximize vehicle operating efficiency? No, because the efficiency gained by designing roads for high average speeds would be negated by an increase in miles traveled. Development can and would become ever more dispersed. The phenomena of induced traffic and induced development are discussed in Chapter 5. Moreover, the most efficient speed for today's cars is probably higher than the most efficient speed for tomorrow's cars. Emission rate curves for hybrid vehicles, in particular, look different, because these vehicles experience less of a low-speed emissions penalty.

### 2.3.3 Synthesis

With the transition from sprawl to compact development, both VMT and VT would be expected to decline, though by different percentages. The result would be a drop in $CO_2$ emissions per capita. Vehicle trips will decline as travelers shift from the automobile to alternative modes, and VMT will decline as mode shifts occur and as automobile trips get shorter. Vehicle operating speeds also may decline, and would have an opposite effect on $CO_2$ emissions per capita. Compact development may mean lower cruising speeds and more stop-and-go driving, hence higher emissions per mile traveled (assuming conventional vehicle technology).

We can get a sense of the magnitude of these effects based on available information. All else being equal, there is a one-to-one relationship between VMT and $CO_2$ emissions; a 30 percent reduction in VMT will result in a 30 percent reduction in $CO_2$ emissions.

**Figure 2-7 Close Relationship between VMT per Household and $CO_2$ Emissions in the Chicago Metropolitan Area**
*Source: Center for Neighborhood Technology undated.*




Let us posit that regional density will be 50 percent higher in 2050 under compact development than with current trends, a not unreasonable assumption, given the data presented in section 1.7. Given an elasticity of peak hour speed with respect to density of –0.15 (see subsection 3.1.4), the average peak hour vehicle operating speed might decline by 0.15 times 50 percent, or 7.5 percent, with compact development. If so, average daily speed would decline by about 3 percent, since the morning and afternoon peak periods represents two-fifths of average daily traffic in metropolitan areas. Such a decline would cause a 1 to 2 percent increase in $CO_2$ emissions per mile at typical urban speeds (see subsection 2.3.2). Therefore, if compact development reduced VMT by 30 percent, lowered average vehicle operating speed by 3 percent, and had no effect on vehicle trips, the net impact would be a 28 percent drop in $CO_2$ emissions.[19]

The next chapter addresses the extent to which compact urban development can reduce VMT and associated $CO_2$ emissions.

[19] 100% – (70% [VMT] x 102% [$CO_2$ per mile] x 96.7% [running emissions] + 3.3% [start emissions]).

# 3. The Urban Development/VMT Connection

Four different rich empirical literatures inform the discussion of urban development and its impacts on VMT, the primary determinant of transportation-related $CO_2$ emissions:

- aggregate travel studies, such as sprawl index research conducted for Smart Growth America;
- disaggregate travel studies, such as Smart Growth Index elasticity estimates;
- regional simulation studies, such as Portland's LUTRAQ (Land Use, Transportation, Air Quality) study; and
- project simulation studies, such as the EPA's Atlantic Steel study.

In this chapter, we review each literature in turn and present order-of-magnitude effect sizes. For two literatures—disaggregate travel studies and regional simulation studies—the sample of studies is large enough to permit meta-analyses of study results. A meta-analysis is a special kind of literature synthesis, conducted most often in scientific fields. It is more than a literature review, as it generalizes across studies quantitatively, taking individual studies as units of analysis and combining study results to arrive at average effect sizes and confidence intervals.

The different literatures provide a consistent picture. Compact development has the potential to reduce VMT per capita by anywhere from 20 to 40 percent relative to sprawl. The actual reduction in VMT per capita will depend on the specific form of compact development, as outlined in the following sections.

## *3.1 Aggregate Travel Studies*

For decades, it has been known that compact areas have lower levels of automobile use per capita and greater use of alternative modes of transportation than do sprawling areas. They also tend to generate shorter trips. The combined effect is significantly less VMT per capita in compact areas (see Figure 3-1). This fact has been documented most famously by Newman and Kenworthy (1989a, 1989b, 2006, 2007), Holtzclaw (1991, 1994), and Holtzclaw et al. (2002). This same-shaped exponential decline in vehicular travel with density is found in many data series (see Figures 3-2 and 3-3 for communities in the Baltimore area and for higher-income cities worldwide).

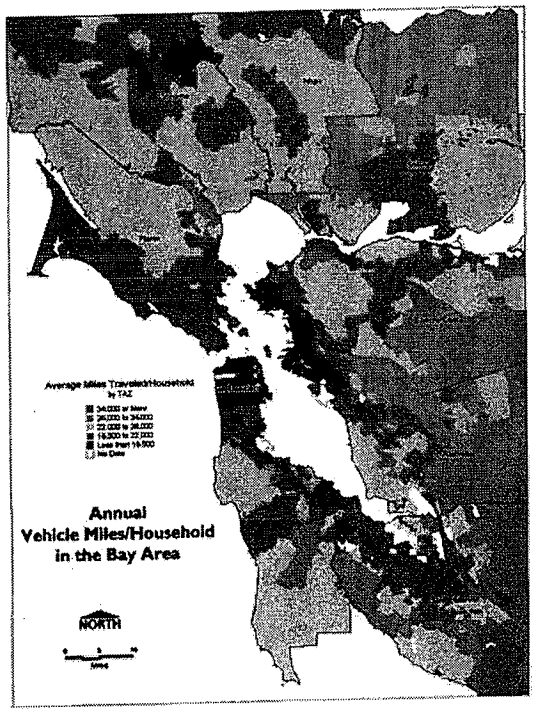



**Figure 3-1 Vehicle Miles Traveled per Household for Neighborhoods in the San Francisco Metropolitan Area**
*Source: Holtzclaw et al. 2002.*

**Figure 3-2 Vehicle Miles Traveled per Capita versus Residential Density for Baltimore Neighborhoods**
*Source: Baltimore Metropolitan Council, 2001 Travel Survey.*

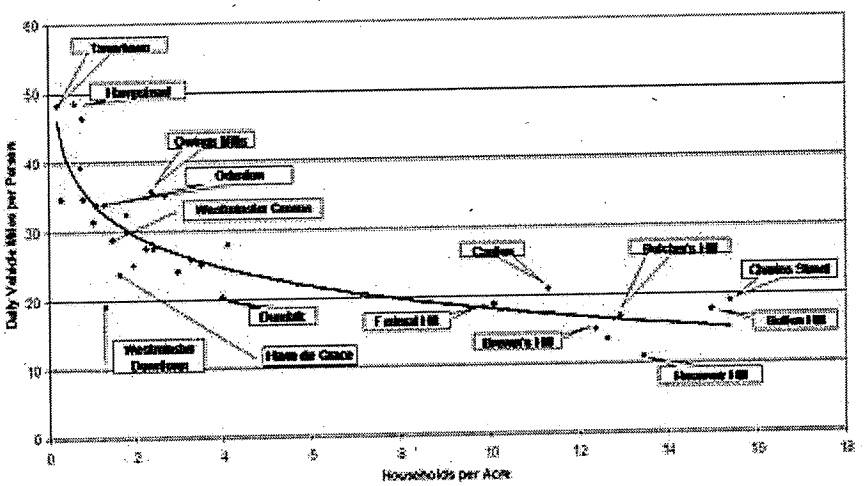
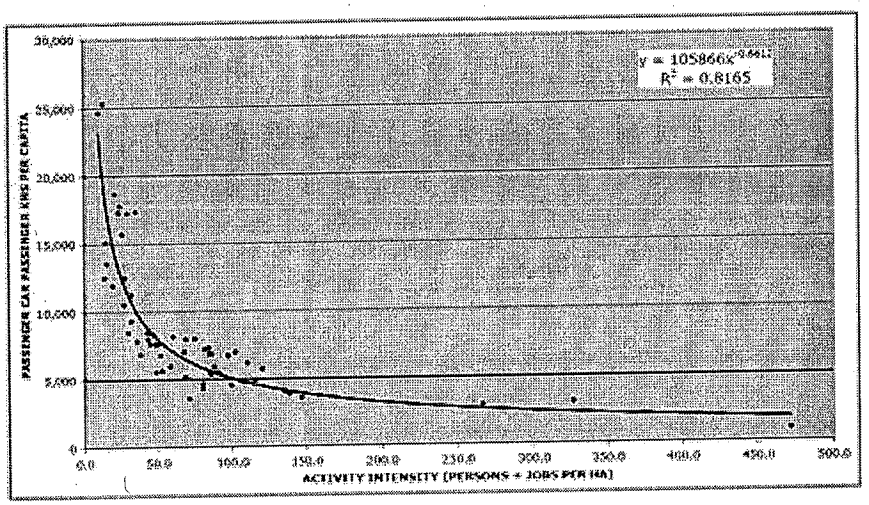



**Figure 3-3 Vehicle Kilometers Traveled per Capita versus Activity Intensity for 58 Higher-Income Cities** *Source: Newman and Kenworthy 2006.*

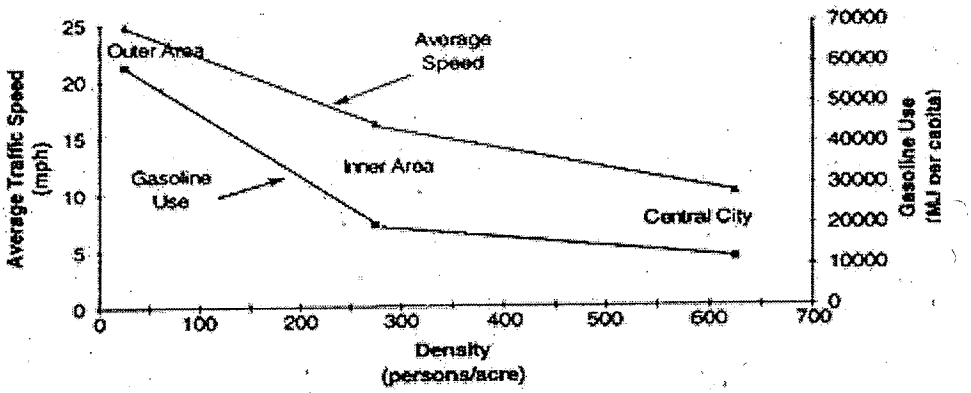



Four facts, however, preclude broad generalizations about urban development patterns and fuel consumption or $CO_2$ emissions. First, dense areas may experience more congestion and lower travel speeds than sprawling areas, hence lower vehicle fuel economy for whatever VMT they produce. Second, dense areas may have different population characteristics than sprawling areas, differences that could confound urban development and travel relationships. Third, density is only one aspect of urban form, albeit an important one. Urban sprawl is defined more broadly as any development pattern in which homes, workplaces, stores, schools, and other activities are widely separated from one another. Fourth, any relationships that appear in aggregate statistics

for neighborhoods, cities, or metropolitan areas would not necessarily apply to individual households, the ultimate travel decision makers.[20]

In a paper entitled "The Transport Energy Trade-Off: Fuel-Efficient Traffic versus Fuel-Efficient Cities," Newman and Kenworthy (1988) addressed the first of these qualifiers. They concluded that the lower VMT in compact areas overwhelms any effect of lower vehicle fuel economy (see Figure 3-4). They subsequently substantiated this relationship for many other places (Newman 2006; Newman and Kenworthy 2006, 2007).

**Figure 3-4. Per Capita Gasoline Consumption in Inner and Outer Portions of the New York Metropolitan Area**
*Source: Newman and Kenworthy 1988.*

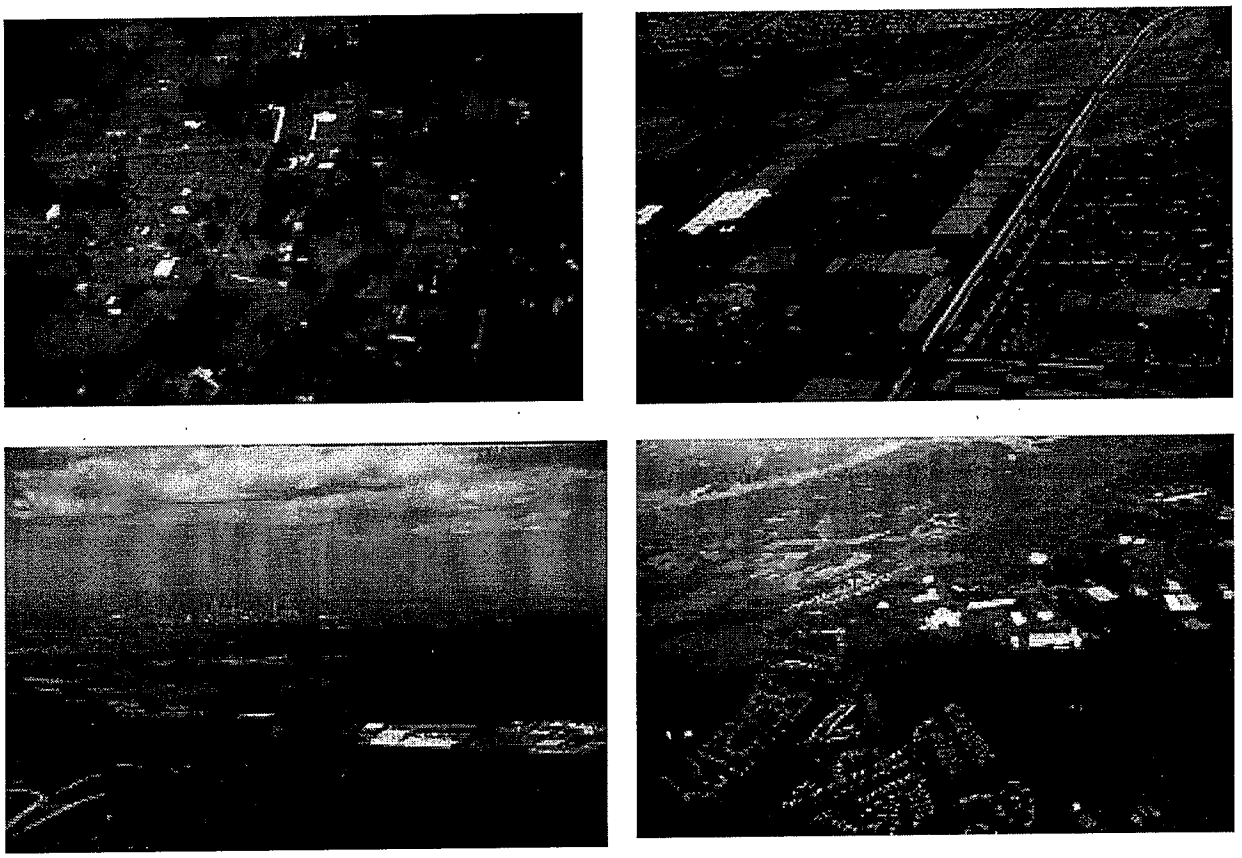



The second qualifier is not so easily dismissed. In Figures 3-2 through 3-4, residential density is not the only characteristic that distinguishes Taneytown from Charles Street in the Baltimore metropolitan area, or one higher-income city from another, or the inner and outer areas of the New York metropolitan area. Culture, socioeconomics, demographics, transit availability, and even gas prices could account for most or all of the differences in per capita vehicle use. Critics of these early studies argued, correctly, that until these other factors were controlled, the independent effect of urban development patterns would be unknown and unknowable (Gomez-Ibanez 1991; Gordon and Richardson 1989).

Likewise, the third qualifier also is not easily dismissed. If poor accessibility is the common denominator of sprawl, then sprawl is more than low-density development. The term also encompasses scattered or leapfrog development, commercial strip development, and single-use development such as bedroom communities. In scattered or leapfrog development, residents and service providers must pass vacant land on their way from one developed area to another. In classic strip development, consumers must pass other uses on the way from one store to the next; this is the antithesis of multipurpose travel to an activity center. In a single-use development, of course, different uses are located far apart as a result of the segregation of land uses. Poor accessibility also could be a product of fragmented street networks that separate urban activities more than need be (see the photos below of sprawling development patterns).

[20] This is due to the so-called ecological fallacy. The ecological fallacy is a widely recognized error in the interpretation of statistical data, whereby inferences about individuals are based solely upon aggregate statistics for the group to which those individuals belong.

*Sprawling development patterns include low-density and single-use development (top left), uncentered strip development (top right), scattered and leapfrog development (bottom left), and sparse street networks (bottom right).*



The fourth qualifier has led to a host of studies using disaggregate travel data; that is, data for individuals or households. Such studies are summarized in section 3.2. For now, the focus is on aggregate relationships, where the unit of analysis is the place.

### 3.1.1 Measuring Urban Sprawl

Around 2000, researchers began to measure the extent of urban sprawl. Their initial attempts were crude. For example, *USA Today*—on the basis of an index presented in its February 22, 2001, issue—declared: "Los Angeles, whose legendary traffic congestion and spread-out development have epitomized suburban sprawl for decades, isn't so sprawling after all. In fact, Portland, OR, the metropolitan area that enacted the nation's toughest antigrowth laws, sprawls more." Indeed, according to *USA Today*'s index, even the New York metropolitan area sprawls more than Los Angeles (Nasser and Overberg 2001).

The most notable feature of these early studies was their failure to define sprawl in all its complexity. Population density is relatively easy to measure, and hence served as the sole indicator of sprawl in several studies. Judged in terms of average population density, Los Angeles looks compact; it is the endless, uniform character of the city's density that makes it seem so sprawling. Another notable feature of these studies was the wildly different sprawl ratings given to different metropolitan areas by different analysts. With the exception of Atlanta, which always seems to rank among the worst, the different variables used to measure sprawl led to very different results. In one study, Portland was ranked as most compact and Los Angeles was way down the list. In another, their rankings were essentially reversed.

Meanwhile, others were developing more complete measures of urban sprawl. Galster et al. (2001) characterized sprawl in eight dimensions: density, continuity, concentration, clustering, centrality, nuclearity, mixed use, and proximity. The condition—sprawl—was defined as a pattern of land use that has low levels in one or more of these dimensions. Each dimension was operationally defined, and six of the eight were quantified for 13 urbanized areas. New York and Philadelphia ranked as the least sprawling of the 13, and Atlanta and Miami as the most sprawling.

Since then, Galster and his colleagues have extended their sprawl measures to 50 metropolitan areas, and are closing in on 100. Their recent work confirms the multidimensional nature of sprawl. In one study, metropolitan areas were ranked in 14 dimensions, some related to population, others to employment, and still others to both (Cutsinger et al. 2005). The 14 dimensions were reduced to seven factors through principal components analysis. Metropolitan areas ranking near the top on one factor were likely to rank near the bottom on another. Los Angeles, for example, ranked second on both "mixed use" and "housing centrality," but 48th on "proximity" and 49th on "nuclearity." With so many variables and esoteric names, this type of analysis can get very confusing.

Building on this work, Cutsinger and Galster (2006) identified four distinct sprawllike patterns among the 50 metropolitan areas: 1) deconcentrated, dense areas; 2) leapfrog areas; 3) compact, core-dominant areas with only moderate density; and 4) dispersed areas. Since none of the 50 metropolitan areas exhibited uniform sprawllike patterns in all dimensions, the authors judged it incorrect to treat sprawl as a single phenomenon.

Multidimensional sprawl indices also were developed for the U.S. EPA and Smart Growth America. They defined sprawl as any environment with 1) a population widely dispersed in low-density residential development; 2) a rigid separation of homes, shops, and workplaces; 3) a lack of major employment and population concentrations downtown and in suburban town centers and other activity centers; and 4) a network of roads marked by very large block size and poor access from one place to another. These indices were used to measure sprawl for 83 of the nation's largest metropolitan areas (Ewing, Pendall, and Chen 2002, 2003).

Principal components analysis was used to reduce 22 land use and street network variables to four factors representing these four dimensions of sprawl, each factor being a linear combination of the underlying operational variables.[21] The four factors represent a balanced scorecard of sprawl indicators. "Density" and "mix," while correlated, are very different constructs, as are "centeredness" and "street accessibility." The four factors were combined into an overall metropolitan sprawl index.

A simpler county sprawl index also was developed to measure the built environment at a finer geographic scale, the individual county. This index is a linear combination of six variables from the larger set, these six being available for counties, whereas many of the larger set were available only for metropolitan areas.[22] Initially calculated for 448 metropolitan counties (McCann and Ewing 2003), the index is now available for 954 metropolitan counties or county equivalents representing 82 percent of the nation's population (Ewing, Brownson, and Berrigan 2006).

All sprawl indices were standardized, with mean values of 100 and standard deviations of 25. The way the indices were constructed, the bigger the value of the index, the more compact the metropolitan area or county; the smaller the value, the more sprawling the metropolitan area or county. Thus, in the year 2000, the New York metropolitan statistical area had an index value of 178, while Atlanta had a value of 58. Manhattan had an index value of 352, while Geauga County (outside Cleveland) had a value of 63 (see photographs below).

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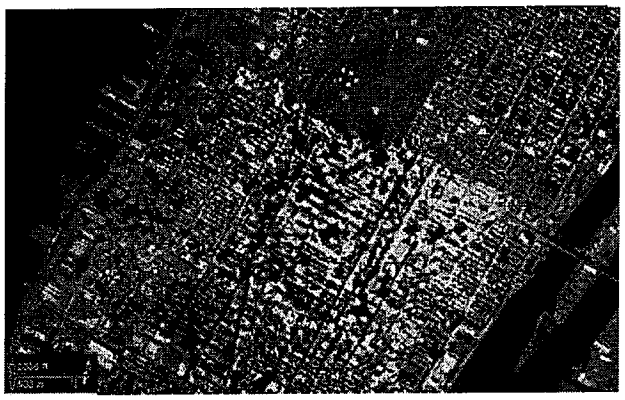
[21] "Residential density" was defined in terms of gross and net densities and proportions of the population living at different densities; seven variables made up the metropolitan density factor. "Land use mix" was defined in terms of the degree to which land uses are mixed and balanced within subareas of the region; six variables made up this factor. "Degree of centering" was defined as the extent to which development is focused on the region's core and regional subcenters; six variables made up this factor. "Street accessibility" was defined in terms of the length and size of blocks; three variables made up this factor.

[22] The six variables are as follows: 1) gross population density (persons per square mile); 2) percentage of the county population living at low suburban densities, specifically, densities between 101 and 1,499 persons per square mile, corresponding to less than one housing unit per acre; 3) percentage of the county population living at moderate to high urban densities, specifically, more than 12,500 persons per square mile, corresponding to about eight housing units per acre, the lower limit of density needed to support mass transit; 4) the net density in urban areas, which was derived from the estimated urban land area for each county; 5) average block size; and 6) percentage of blocks with areas less than 1/100 of a square mile, the size of a typical traditional urban block bounded by sides just over 500 feet in length.

*Satellite photographs show the nation's most compact county—New York County, also known as Manhattan—at left and its most sprawling county—Geauga County, Ohio—at right. Both photographs are presented at the same scale.*
*Source: www.maps.google.com*



### 3.1.2 Relating Urban Sprawl to Travel Outcomes

The study for the EPA and Smart Growth America analyzed relationships between sprawl and various travel outcomes. The overall sprawl index showed strong and statistically significant relationships to six outcome variables. All relationships were in the expected directions. As the index increases (that is, as sprawl decreases), average vehicle ownership, daily VMT per capita, the annual traffic fatality rate, and the maximum ozone level decrease to a significant degree. At the same time, shares of work trips by transit and walk modes increase to a significant degree.

The significance of these relationships rivaled or, in some cases, actually exceeded that of the sociodemographic control variables. The index was the only variable that rose to the level of statistical significance for walk share of work trips and maximum ozone level, and had the strongest association to daily VMT per capita and the annual traffic fatality rate. It had secondary, but still highly significant, associations with average vehicle ownership and transit share of work trips.

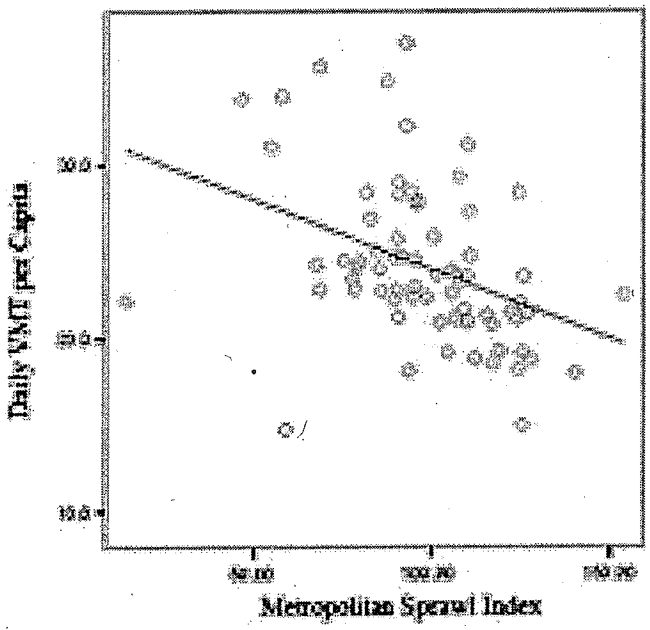
Obviously, these relationships are not independent of each other. The lower level of vehicle ownership in dense metropolitan areas contributes to higher mode shares for alternatives to the automobile. These, in turn, contribute to lower VMT, which contributes to lower traffic fatalities and ozone levels. Because of the different data sources, units of analysis, and sample sizes, it would be treacherous to model the causal paths among these outcome variables. But, intuitively, they should be related as indicated.

### 3.1.3 Sprawl versus VMT

The relationship between the overall metropolitan sprawl index and VMT per capita is plotted in Figure 3-5. The simple correlation is significant. The more compact an area (the larger the index value), the lower the VMT per capita.

**Figure 3-5 Simple Correlation between Daily VMT per Capita and Metropolitan Sprawl Index***
*Source: Ewing, Pendall, and Chen 2002.*

*Larger index values = less sprawl.




Recall that the overall sprawl index is composed of four factors: density, mix, centeredness, and street accessibility (as discussed in section 3.1.1). The density factor has the strongest and most significant relationship to travel and transportation outcomes (see Figure 3-6). It has a significant inverse relationship to average vehicle ownership, VMT per capita, traffic fatality rate, and maximum ozone level, and a significant direct relationship to public transportation and walk shares of commute trips. With the exception of the traffic fatality rate, all relationships are significant at the 0.01 probability level or beyond.

To illustrate the strength of density relationships, a 50-unit increase in the density factor (from one standard deviation below average to one standard deviation above average) is associated with a drop of 10.75 daily VMT per capita (50 x –0.215). That is, controlling for metropolitan population, per capita income, and other factors, the difference between low- and high-density metropolitan areas is more than 10 VMT per capita per day, or 40 percent. Fifty units is roughly the difference in density between San Francisco (denser) and Washington, D.C. (less dense), or between Chicago (denser) and St. Louis (less dense).

The centeredness factor has the next most significant environmental influence on travel and transportation outcomes. It is inversely related to annual delay per capita and traffic fatality rate, and is directly related to public transportation and walk shares of commute trips. These associations are in addition to—and independent of—those of density, which is controlled in the same equations.

The relationship between degree of centering and VMT per capita is just short of significant at the 0.05 level. A 50-unit increase in the centeredness factor (from one standard deviation below the average to one standard deviation above) is associated with a 2.3 daily VMT per capita (50 x –0.0462), about one-quarter the change associated with the density factor. The two effects are additive. Fifty units is roughly the difference in degree of centering between New York (more centered) and Philadelphia (less centered), or between Portland (more centered) and Los Angeles (less centered).

**Figure 3-6 Transportation Outcomes versus Sprawl Factors***
*Source: Ewing, Pendall, and Chen 2002*

| | Transportation Outcomes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *Vehicles per Household* | *Transit Share of WorkTrips* | *Walk Share of WorkTrips* | *Mean Travel Time to Work* | *Annual Delay per Capita* | *VMT per Capita* | *Fatalities per 10,0000 Population* | *Peak Ozone Level* |
| *Density factor* | – – | ++ | ++ | | | – – | – | – – |
| *Mix factor* | | | | – | | | – | + |
| *Centers factor* | – – | ++ | ++ | – | – | – | – | – |
| *Streets factor* | | | | ++ | ++ | | | |
| *Metro population* | | + | | ++ | + | | | ++ |
| *Average household size* | + | | | ++ | ++ | | | |
| *Percentage of working age* | ++ | | | | ++ | + | | |
| *Per capita income* | | ++ | | ++ | | | – | |
| **Adjusted $R^2$** | 0.56 | 0.67 | 0.36 | 0.61 | 0.63 | 0.28 | 0.44 | 0.40 |

*+ indicates a positive relationship significant at the 0.05 probability level; ++ a positive relationship significant at the 0.01 probability level; – a negative relationship significant at the 0.05 probability level; and – – a negative relationship significant at the 0.01 probability level.

The mix factor is significant for only three transportation outcomes: as a mitigating influence on travel time to work and fatal accidents and an aggravating influence on the maximum ozone level. The big surprise is that land use mix does not significantly affect other outcomes, including VMT per capita. It may be that land use mix has not been successfully operationalized because of problems with the underlying data sets (Ewing, Pendall, and Chen 2002).

The streets factor is significant for two transportation outcomes, albeit just barely and with unexpected signs. Average travel time for commute trips and annual traffic delay per capita are directly related to the streets factor. Perhaps the reason for this counterintuitive result is that the additional intersections in metro areas with dense street grids translate into more total delay, since most delays occur at intersections rather than on the stretches between them. This is the conventional wisdom among traffic engineers. In any case, street patterns appear to be much less important than land use patterns as correlates of travel and transportation outcomes.

### 3.1.4 Sprawl versus Congestion

It has been argued that the dispersal of jobs and housing allows residents to live closer to their workplaces than they could if jobs were concentrated in downtown and other centers. It also has been argued that the dispersal of jobs and housing eases traffic congestion by dispersing origins and destinations. These effects, if dominant, would lead to shorter trips and less congestion in sprawling metro areas. But the dispersal of jobs and housing also may result in jobs/housing imbalances across the region, cross commuting, and significantly more VMT per capita than with more compact urban development. The average commute has been getting steadily longer in miles and minutes (Hu and Reuscher 2004). The net effect of sprawl on traffic congestion is unclear a priori.

Evidence from aggregate travel studies suggests that density aggravates congestion, but not much. One study found that congestion rises with population density for counties in California (Boarnet, Kim, and Parkany 1998). Urbanized counties as a group are more congested than rural counties. However, this same study found "surprisingly congested counties that are either rural or on the fringe of urban areas." These fringe counties generate a lot of VMT. We reanalyzed congestion data from that study and, excluding one outlier, computed an elasticity of congestion with respect to density of 0.14.

Another study found little relationship between density and commute time in the largest urban areas (Gordon, Kumar, and Richardson 1989). "Travel times may be long in high- or low-density cities (e.g., New York or Houston) or short (e.g., Los Angeles or Dallas)." Basically, shorter trips and mode shifts in dense areas largely offset any effect of lower speeds.

The Texas Transportation Institute's Urban Mobility database for 85 urbanized areas also shows a weak relationship between density and congestion (Schrank and Lomax 2005). TTI measures congestion in terms of a travel time index; that is, the ratio of travel time in the peak period to travel time at free-flow conditions. A value of 1.35 indicates that a 20-minute free-flow trip takes, on average, 27 minutes in the peak period. In a cross-sectional analysis for 2003, the last year in the series, the elasticity of travel time with respect to population density is 0.085. This elasticity estimate controls for population size because bigger cities have more congestion regardless of their urban form. In a longitudinal analysis for the same 85 urbanized areas using the full TTI data series (1982 to 2003), the elasticity of change in travel time with respect to change in density is 0.107. This elasticity estimate controls for population growth because fast-growing areas have more congestion regardless of how they grow.

Such studies have been criticized for focusing on only one dimension of sprawl: "Other land use dimensions are less well studied in a comparative framework . . . while it is believed that land use patterns may play an important role in mitigating or slowing the growth of congestion in urban areas, few studies have explored the relationship between land use and congestion across more than a small number of urban areas or examined multiple measures of land use beyond population density" (Sarzynski et al. 2006).

In the Smart Growth America study, sprawl factors pulled in opposite directions (Ewing, Pendall, and Chen 2002, 2003). The overall sprawl index was not significantly related to either average commute time or annual traffic delay per capita. Both outcomes were a function primarily of metropolitan area population, and secondarily of other sociodemographic variables. Big metro areas generate longer trips to work and higher levels of traffic congestion. After controlling for population size and other sociodemographic variables, sprawl (overall) did not appear to have an effect on average commute time or annual traffic delay per capita.

Using the same overall metropolitan sprawl index as Ewing, Pendall, and Chen (2002), Kahn (2006) divided metropolitan areas into four categories and found that, relative to workers in compact metro areas, workers in sprawling ones commute an extra 1.8 miles each way. But their commute is still 4.3 minutes shorter; the extra commute distance is more than offset by higher travel speeds. Indeed, commute speed is estimated to be 9.5 mile per hour higher in the sprawling metro areas.

Why is there a difference in the sprawl/commute time relationship between two studies that test the same overall sprawl index? The first study uses U.S. Census commute data, the second American Housing Survey commute data. The first study treats sprawl as a continuous variable, the second as a categorical variable. Whatever their differences, both studies suggest higher VMT in sprawling metro areas than in compact ones.

Another recent study, by Galster and colleagues, related seven dimensions of sprawl to traffic congestion for 50 large metropolitan areas in 2000 (Sarzynski et al. 2006). Controlling for 1990 levels of congestion and changes in an urban area's transportation network and relevant demographics, the study found that density and housing centrality were positively related to year 2000 delay per capita and that housing/job proximity was negatively related to year 2000 commute time.

Differences between this and earlier studies may be due to the use of a lagged model structure, different land use measures, or a different sample of metropolitan areas. Since Sarzynski et al. were unable to study the effect of land use changes between 1990 and 2000 (for lack of sprawl indices for 2000), it is hard to interpret the coefficients of a lagged model. Relationships to delay could be bogus in all of these studies, since the delay measure used by everyone comes from the Texas Transportation Institute and is imputed rather than actually measured in the field. Considering all the evidence from aggregate travel studies, it is reasonable to assume some drop in average travel speeds with rising density. From this literature, we cannot draw any conclusions about travel speeds versus land use mix or other dimensions of sprawl.

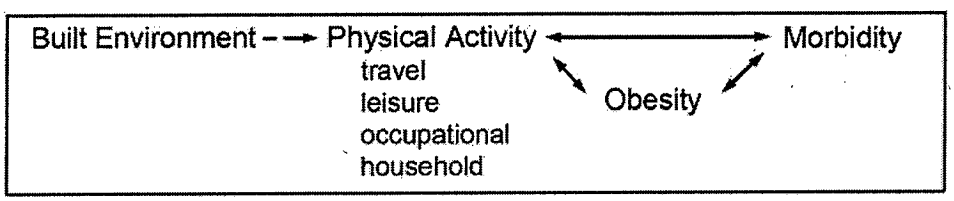
## *3.2 Disaggregate Travel Studies*

Land use/travel studies date from the early 1960s, when urban density was first shown to affect auto ownership, trip rates, and travel mode shares. Around 1990, researchers began to use disaggregate travel data for individuals or households; made some effort to control for other influences on travel behavior, particularly the socioeconomic status of travelers; and tested a wider variety of local land use variables than had earlier studies.

The relationship between urban development patterns and individual or household travel has become the most heavily researched subject in urban planning. There are now close to 100 empirical studies conducted with a degree of rigor—that is, with decent sample sizes, sociodemographic controls, and statistical tests to determine the significance of the various effects (see literature reviews by Badoe and Miller (2000); Crane (2000); Ewing and Cervero (2001); Saelens, Sallis, and Frank (2003); and Heath et al. (2006)). The vast majority of these studies show significant relationships between development patterns and travel behavior. Today, only the direction of causality and strength of effects seems to be seriously debated.

When funding from public health sources became available after 2000, planning researchers morphed into physical activity researchers, and the literature grew even further (see reviews by Frank (2000), Frank and Engelke (2001, 2005), Lee and Moudon (2004), Owen et al. (2004), Badland and Schofield (2005), and Handy (2006)). Both types of physical activity—for transportation and for exercise—were studied together for the first time, and the physical environment was measured comprehensively in terms of development patterns and physical activity settings (see Figure 3-7). Again, nearly all studies show significant relationships. And, again, the debate is mainly over the direction of causality and effect sizes. A special Winter 2006 issue of the *Journal of the American Planning Association* was devoted to this new research.

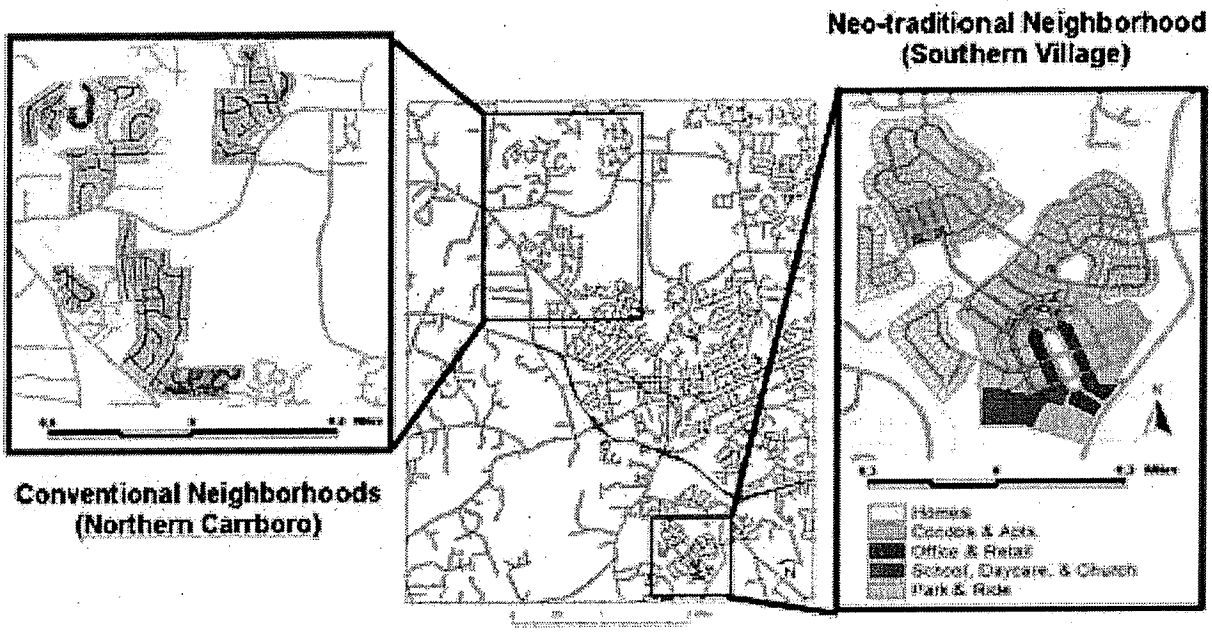
**Figure 3-7 Causal Pathways Linking the Built Environment to Health**
*Source: Ewing et al. 2003.*



### 3.2.1 Accessibility Again

The concept of sprawl seems particularly tailored to large areas such as metropolitan areas and their component counties. The degree to which employment is concentrated in central business districts or suburban centers, for example, is a characteristic of an entire metro area, not of an individual community or neighborhood. Yet there are analogous measures for subareas as small as neighborhoods (see Figure 3-8), and these analogous measures have been studied in depth for their relationships to trip frequency, trip distance, and mode choice.

**Figure 3-8 Neighborhoods with Different Designs and Travel Characteristics in Chapel Hill, North Carolina**
*Source: Khattak and Rodriquez 2005.*




Accessibility influences the way household needs are met through travel. Two types of accessibility have been shown to be significant. One is ease of access to activities from one's place of residence, the other ease of access to activities from other activities.

Residential accessibility affects the destination, mode and, arguably, even the frequency of home-based trips. It has been the focus of nearly all travel and physical activity research. However, the relevant environment for many trips is someplace other than home. Non–home based trips account for 25 to 30 percent of trips in most urban areas, and the percentage is growing as people's complex lives cause them to link trips into complex tours.

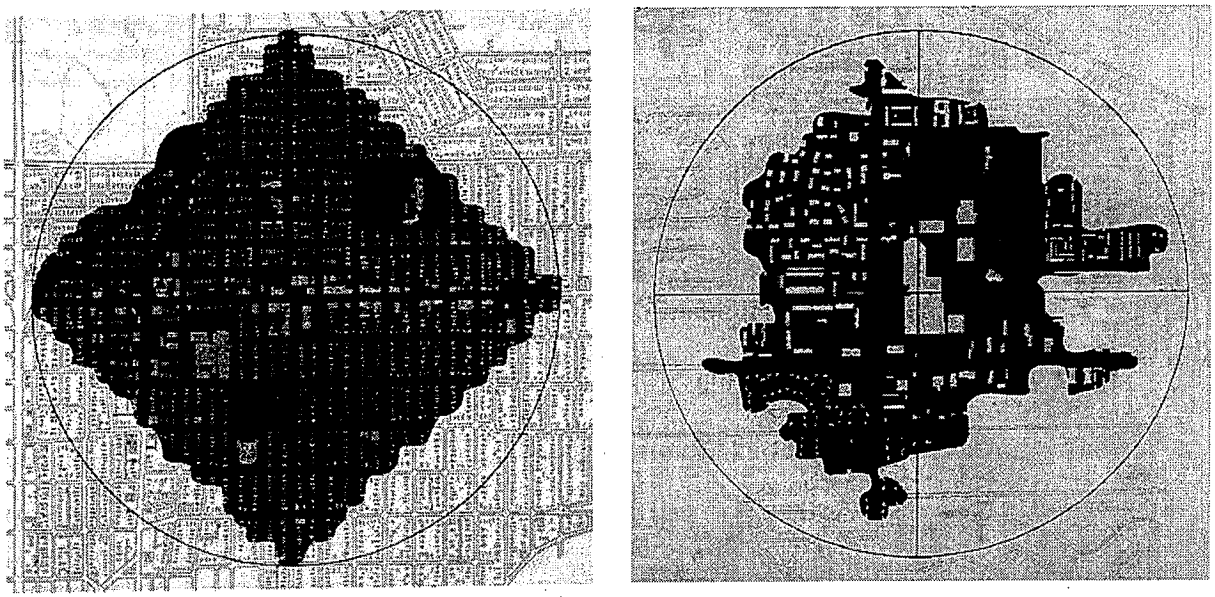
Trip chaining, or the linking of trips into tours, has been increasing over time (Levinson and Kumar 1995; McGuckin, Zmud, and Nakamoto 2005). Trips are more likely to be linked into long tours in areas of poor residential accessibility, simply because this is a way for households living in sprawl to economize on travel (Ewing, Haliyur, and Page 1994; Ewing 1995; Krizek 2003; Limanond and Niemeier 2004; Noland and Thomas 2006). The more sprawling the area, the more important it becomes to concentrate common destinations in centers, so a single auto trip can meet multiple needs. Conservatively, the ability to link trips in tours cuts overall household travel by 15 to 22 percent relative to separate trips for the same purposes (Oster 1978).

### 3.2.2 Measuring the Five Ds

In travel research, urban development patterns have come to be characterized by "D" variables. The original "three Ds," coined by Cervero and Kockelman (1997), are density, diversity, and design. The Ds have multiplied since then, with the addition of destination accessibility and distance to transit. If we could think of an appropriate label, parking supply and cost might be characterized as a sixth D.

Density usually is measured in terms of persons, jobs, or dwellings per unit area. Diversity refers to land use mix. It often is related to the number of different land uses in an area and the degree to which they are "balanced" in land area, floor area, or employment. Design includes street network characteristics within a neighborhood (see Figure 3-9). Street networks vary from dense urban grids of highly interconnected, straight streets to sparse suburban networks of curving streets forming "loops and lollipops." Street accessibility usually is measured in terms of average block size, proportion of four-way intersections, or number of intersections per square mile. Design also is measured in terms of sidewalk coverage, building setbacks, streets widths, pedestrian crossings, presence of street trees, and a host of other physical variables that differentiate pedestrian-oriented environments from auto-oriented ones.

**Figure 3-9 Destinations within One-Quarter Mile of Center for Contrasting Street Networks in Seattle**
*Source: Moudon et al. 1997.*



Destination accessibility is measured in terms of the number of jobs or other attractions reachable within a given travel time, which tends to be highest at central locations and lowest at peripheral ones. Distance to transit usually is measured from home or work to the nearest rail station or bus stop by the shortest street route.

### 3.2.3 D Variables versus VMT and VT

The D variables have a significant effect on the overall VMT and VT of individuals and households, mostly through their effect on the distance people travel and the modes of travel they choose (Ewing and Cervero 2001). Trip frequencies appear to be primarily a function of travelers' socioeconomic and demographic characteristics and secondarily a function of the built environment; trip lengths are primarily a function of the built environment and secondarily of socioeconomic and demographic characteristics; and mode choices depend on both, though probably more on socioeconomics.

Trip lengths are generally shorter at locations that are more accessible, have higher densities, or feature mixed uses. This holds true for both the home end (that is, residential neighborhoods) and nonhome end (activity centers) of trips. Alternatives to the automobile claim a larger share of all trips at higher densities and in mixed-use areas. Walk mode shares can rise to 20 percent or more in mixed-use neighborhoods even without high-quality transit service (see Figure 3-10).

These studies indicate that transit use varies primarily with local densities and secondarily with the degree of land use mixing (see Figure 3-11). Some of the density effect is, no doubt, due to shorter distances to transit service. Walking varies as much with the degree of land use mixing as with local densities (see Figure 3-12). An unresolved issue is whether the relationship of density to travel behavior is due to density itself or to other variables with which density co-varies, such as good transit service, limited parking, and so forth.

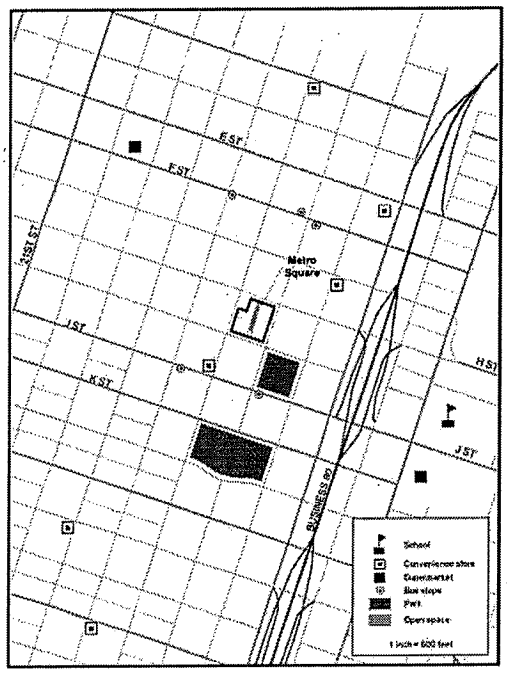



**Figure 3-10 Built Environment and Mode Shares of Metro Square in Sacramento, California**
*Source: NRDC 2000.*

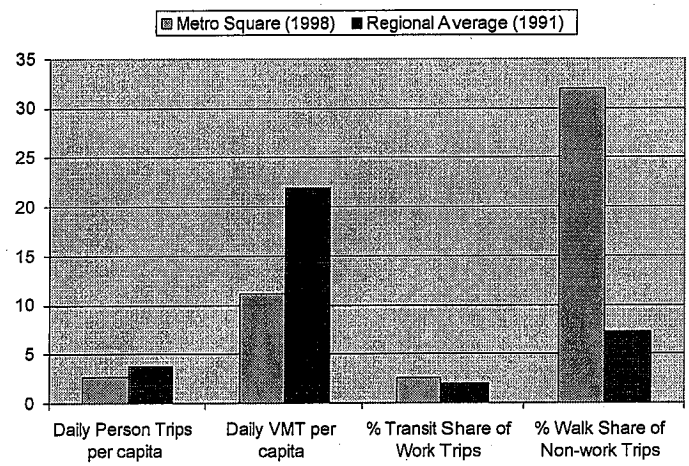
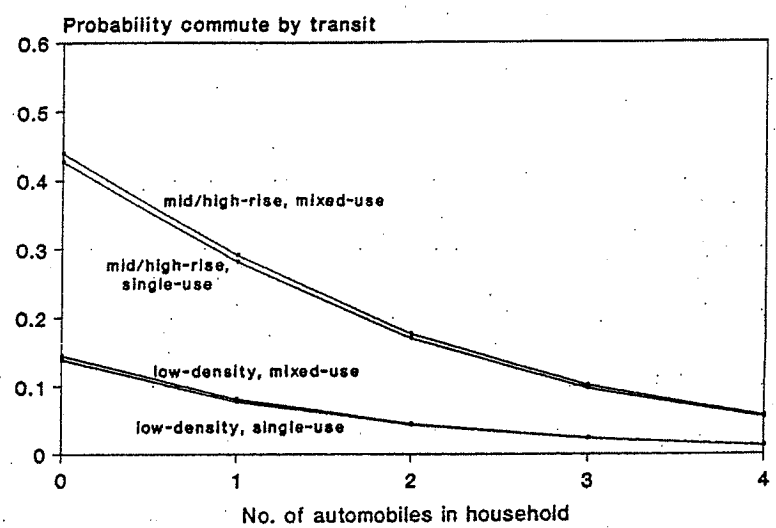


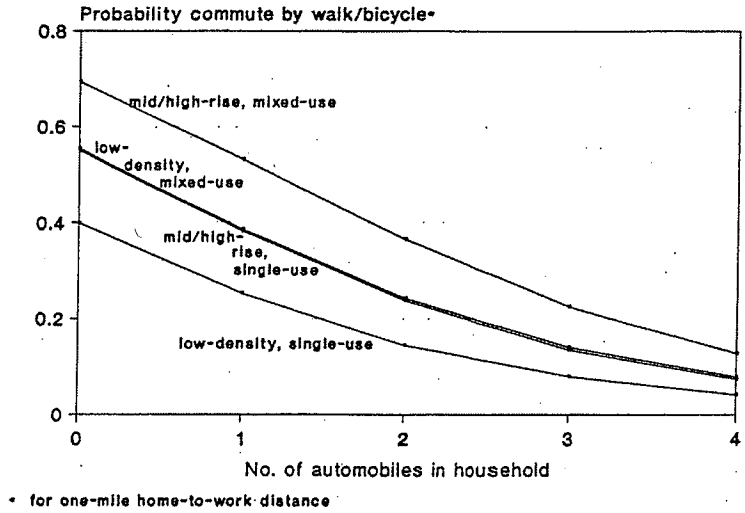

**Figure 3-11 Effects of Density and Mixed Use on Choice of Transit for Commutes***
*Source: Cervero 1996.*




*Data for more than 45,000 U.S. households showed transit use primarily dependent on density of development. At higher densities, the addition of retail uses in neighborhoods was associated with several percentage point higher levels of transit commuting across 11 U.S. metropolitan areas.

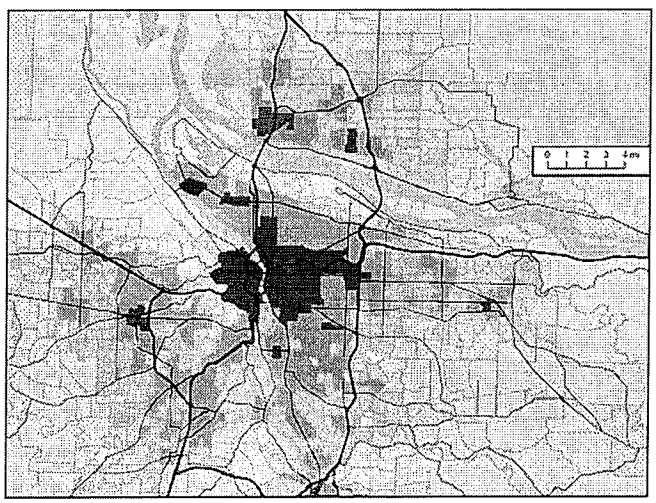
**Figure 3-12 Effects of Density and Mixed Use on Choice of Walk/Bike for Commutes***
*Source: Cervero 1996.*

*Rates of walk and bicycle trips (for a one-mile home-to-work trip) are comparable for low-density, mixed-use neighborhoods as compared with high-density, single-use ones, controlling for vehicle ownership levels.




The third D—design—has a more ambiguous relationship to travel behavior than do the first two. Any effect is likely to be a collective one involving multiple design features. It also may be an interactive effect involving land use and transportation variables. This is the idea behind composite measures such as Portland, Oregon's "pedestrian environment factor" and Montgomery County, Maryland's "transit serviceability index" (see Figure 3-13). Portland's pedestrian environment factor is the sum of four variables related to 1) ease of street crossing, 2) sidewalk continuity, 3) street network connectivity, and 4) topography. Because of the subjective nature of these variables, the pedestrian environment factor has been replaced with an "urban design factor," which is a function of intersection density, residential density, and employment density.

**Figure 3-13 Values of the Urban Design Factor across the Portland Metropolitan Area**
*Source: Portland Metro.*



For 14 carefully controlled travel studies, Ewing and Cervero (2001) synthesized the literature by computing elasticities of VMT and VT with respect to the first four Ds—density, diversity, design, and destination accessibility. These summary measures were incorporated into the EPA's Smart Growth Index (SGI) model, a widely used sketch planning tool for travel and air quality analysis. In the SGI model, density is measured in terms of residents plus jobs per square mile; diversity in terms of the ratio of jobs to residents relative to the regional average; and design in terms of street network density, sidewalk coverage, and route directness (two of three measures relating to street network design). These are just a few of the many ways in which the 3Ds have been operationalized at the neighborhood level (see literature review, Ewing and Cervero 2001).

Figure 3-14 presents elasticities of VT and VMT with respect to the four Ds. An elasticity is a percentage change in one variable with respect to a 1 percent change in another variable. Hence, from the elasticities presented in Figure 3-14, we would expect a doubling of neighborhood density to result in approximately a 5 percent reduction in both VT and VMT, all other things being equal. The effects of the four Ds captured in this table are cumulative. Doubling all four Ds would be expected to reduce VMT by about one-third. Note that the elasticity of VMT with respect to destination accessibility is as large as the other three combined, suggesting that areas of high accessibility—such as center cities—may produce substantially lower VMT than dense mixed-use developments in the exurbs.

**Figure 3-14 Typical Elasticities of Travel with Respect to the Four Ds**
*Source: Ewing and Cervero 2001.*

| | Vehicle Trips (VT) | Vehicle Miles Traveled (VMT) |
|---|---|---|
| Local Density | – .05 | – .05 |
| Local Diversity (Mix) | – .03 | – .05 |
| Local Design | – .05 | – .03 |
| Regional Accessibility | – – | – .20 |

### 3.2.4 Meta-Analysis of Disaggregate Travel Studies

Since Ewing and Cervero's 2001 literature review, the published literature on the built environment and travel has mushroomed. A more recent review identified 40 published studies of the built environment and travel, and selected 17 that met minimum methodological and statistical criteria (Leck 2006). While the analysis stopped short of estimating average effect sizes, it did evaluate the statistical significance of relationships between the built environment and travel. Residential density, employment density, and land use mix were found to be inversely related to VMT at the $p < 0.001$ significance level.

The number of rigorous studies now exceeds 100, including studies examining four or five D variables at once, studies comparing travel behavior across nations, studies focusing on children, and studies accounting for residential preferences that may confound results. The EPA is funding a full-blown meta-study of this ever-expanding literature, which will summarize the most pertinent literature qualitatively and, using standard methods of meta-analysis, will combine individual study results into average elasticities or percentage point adjustments of VMT, VT, and transit use and walking with respect to the D variables. Confidence intervals will be computed for the average values. These summary measures will become available for sketch planning applications.

## *3.3 Regional Growth Simulations*

In the "old days," metropolitan planning organizations (MPOs) developed their plans by testing different transportation alternatives against a single future land use forecast. One alternative might have more highways, another more transit or a new beltway or more arterial street improvements. But future land use patterns were always assumed to be fixed.

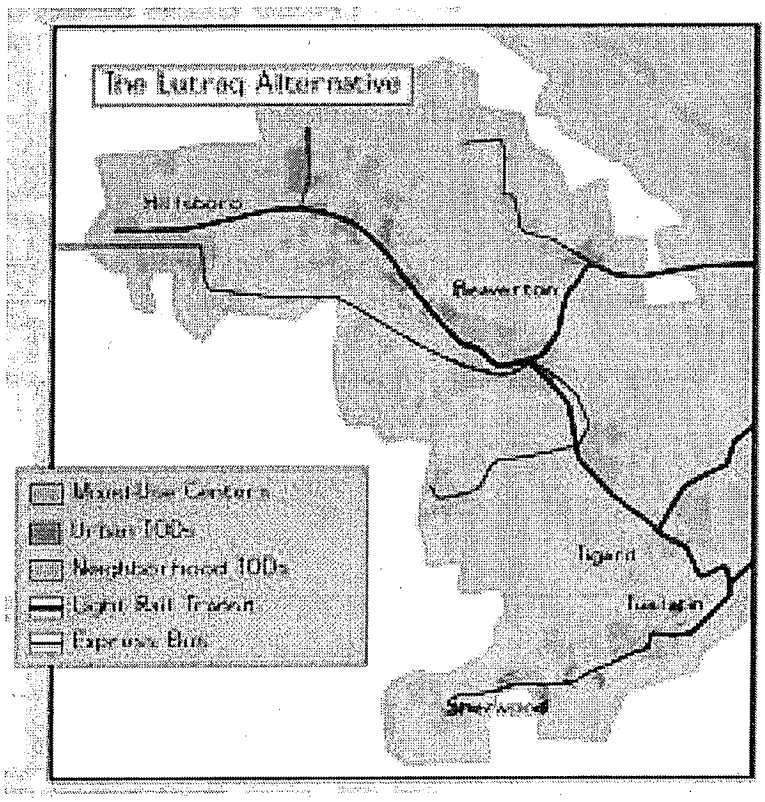
Future land use projections typically were extrapolations of recent trends, assumed to be unaffected by additions to urban infrastructure, most importantly by transportation improvements. In other words, future land use patterns were treated as fixed inputs into the analysis, not as variables or possible outcomes.

All that changed in the early 1990s with the advent of regional scenario planning, which matches alternative land use plans with alternative transportation plans. These plans are run through simulation models to project impacts on VMT, land consumption rates, air pollutant emission levels, housing affordability indexes, and other outcome measures. In theory, the most cost-effective plan is adopted.

### 3.3.1 The Rise of Scenario Planning

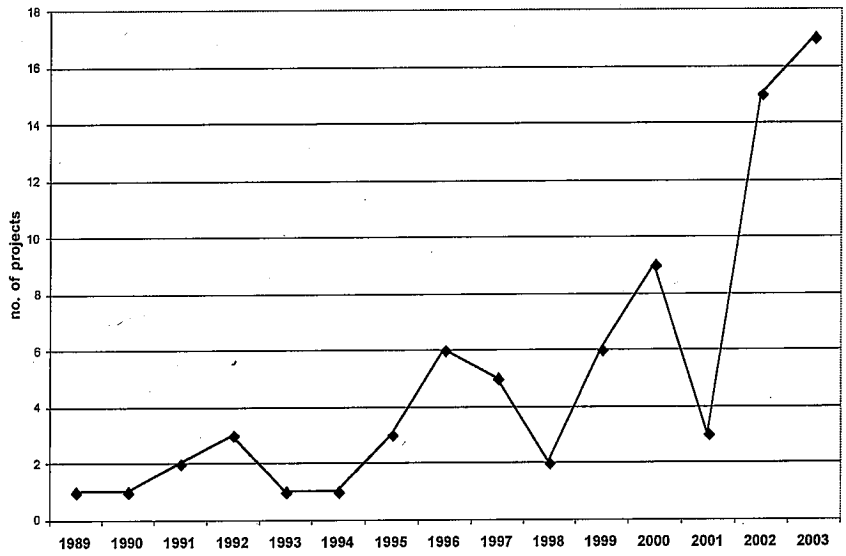
Scenario planning got a major boost from the well-publicized success of Portland, Oregon's Land Use, Transportation, Air Quality (LUTRAQ) study, which called for combining light-rail investments with transit-oriented development and travel demand management policies (1000 Friends of Oregon 1997). Portland Metro, the regional government, turned down a proposed western bypass beltway in favor of the LUTRAQ plan when regional travel forecasts showed the LUTRAQ alternative would produce significantly fewer VMT and lower levels of congestion than would trend development with the new freeway (see Figure 3-15).

**Figure 3-15 The LUTRAQ Plan for the Western Portland Metro**
*Source: 1000 Friends of Oregon 1997.*




The number of scenario planning studies undertaken in the United States has grown dramatically since LUTRAQ (see Figure 3-16). Regional scenario planning has transitioned from state-of-the-art to state-of-the-practice at MPOs (Ewing 2007). Such studies also have become common outside the United States (Johnston 2006). In fact, many advances in integrated land use/transportation modeling have come from outside the United States.

**Figure 3-16 Number of Scenario Planning Projects by Completion Date**
*Source: Bartholomew 2007.*




### 3.3.2 The Scenario Planning Process

The typical scenario planning process compares a "trend" scenario to one or more alternative future "planning" scenarios. In the trend scenario, urban development and transportation investment patterns of the recent past are assumed to continue through the planning horizon (20 to 50 years in the future). The trend scenario—usually some version of urban sprawl—is assessed for its impacts on VMT and other regional outcomes.

This is followed by the formulation of one or more alternative futures that vary with respect to land use and transportation. Compared to the trend scenario, the planning alternatives usually have higher gross densities, mix land uses to a greater extent, and/or channel more development into urban centers. They may incorporate a variety of transportation infrastructure investments and pricing policies. One alternative may invest more in transit lines, another might invest more in high-occupancy-vehicle (HOV) lanes.

These alternative scenarios are then assessed for their impacts using the same travel forecasting models and same set of outcome measures as with the trend scenario. Vehicle miles traveled is almost always among the outcomes forecasted. The resulting comparison of scenarios can provide the basis for rational urban policy development.

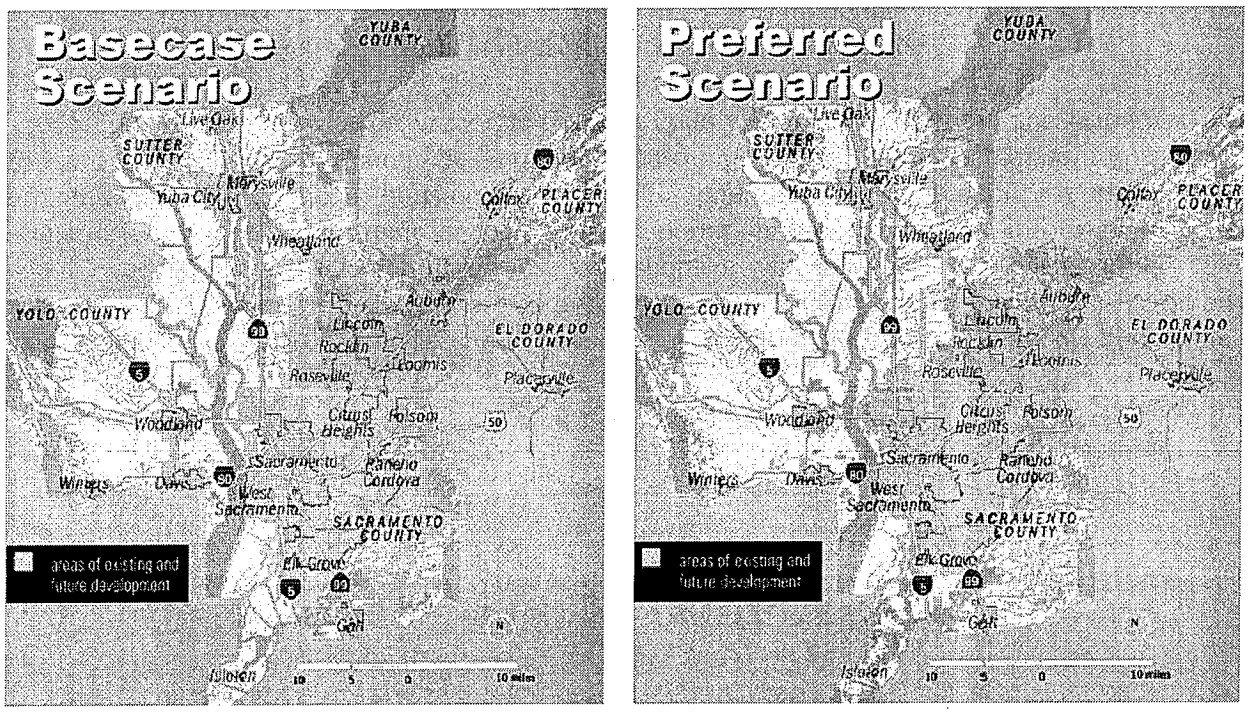
### 3.3.3 Case Study: The Sacramento Region Blueprint Study

A leading example of scenario planning technique comes from the Sacramento region. Concerned about dispersed future growth patterns, housing, transportation, and air quality, the Sacramento Area Council of Governments initiated the Sacramento Region Blueprint Transportation–Land Use Study to craft a future growth strategy for the region (SACOG undated). Scenarios were constructed through a bottom-up process, starting at the neighborhood level. At a series of 25 neighborhood workshops,

citizen participants were shown future "business as usual" development scenarios for their neighborhoods. Participants then were asked to develop a series of smart growth alternative scenarios, which were fed into a geographic information systems (GIS) modeling program that provided real-time assessments of each scenario's land use and transportation impacts.

The neighborhood scenarios provided the basis for countywide scenarios. Four scenarios were crafted for each of the region's six counties—a trend scenario plus three alternatives that combined different growth rates, land use mixes, housing types, densities, and infill/redevelopment proportions. These scenarios were analyzed for their land use and transportation impacts, creating information for several countywide workshops. The output of those workshops provided the basis for four regional-scale scenarios. Regionwide workshops then led to the creation of a fifth scenario—with a substantially smaller urban footprint than the so-called base case or trend—that ultimately was selected as the preferred option (see Figure 3-17).

**Figure 3-17 Urban Footprints of Base Case and Preferred Scenarios for the Sacramento, California, Region**
*Source: SACOG (2005).*




As illustrated in Figure 3-18, transit use and walking/bicycling increase and VMT decreases in the Sacramento region as the levels of density and infill development increase. The preferred scenario from the blueprint project is now being implemented through amendments to local government land use plans and through the region's long-range transportation plan.

**Figure 3-18 Selected Data for Scenarios from the Sacramento Region Blueprint Study**
*Source: SACOG (2005).*

| Scenarios | Single-Family: Multifamily Hou | % Housing Growth throu Infill | % Auto Trips | % Transit | % Walk/Bi | Daily VM per House |
|---|---|---|---|---|---|---|
| A: Business as usual (trend) | 75:25 | 27.0 | 91.0 | 1.6 | 7.3 | 51.08 |
| B: Higher housing densities A, with growth focused at th urban fringe | 67:33 | 39.0 | 83.2 | 4.0 | 12.7 | 37.60 |
| C: Higher housing densities A, with growth focused on central infill sites | 65:35 | 38.3 | 81.8 | 4.8 | 13.4 | 36.70 |
| D: Higher housing and employment densities, with growth focused on central in sites | 64:36 | 44.0 | 79.9 | 4.8 | 15.3 | 35.70 |
| Preferred Scenario | 65:35 | 41.0 | 83.9 | 3.3 | 12.9 | 34.90 |

### 3.3.4 A Sample of Regional Scenario Studies

An open-ended survey was conducted in 2003/2004 to gather information on current and past scenario planning practices (Bartholomew 2007). The survey initially was sent to the planning directors of 658 member organizations in the National Association of Regional Councils (NARC). Additional surveys were sent to members of the Association of Metropolitan Planning Organizations that were not also NARC members. Responses to the two surveys were supplemented by hundreds of e-mails, telephone calls, and Internet searches, resulting in an initial data pool of 153 studies.

This initial pool was subjected to a threshold analysis to determine whether the studies actually used land use/transportation scenario planning techniques. The primary discriminating criterion was whether future land use inputs—such as the density, diversity, design, and destination accessibility of growth—varied across scenarios. Those that held land use patterns static were excluded from the data set. This left a total of 80 studies, spread geographically across the country. Large and fast-growing regions are overrepresented in the sample.

Most studies test three or four scenarios (including a trend scenario) that vary in density, mix, and arrangement of future land uses. Half of the studies also test alternative transportation infrastructure investments. Twelve incorporate a transportation pricing element. Three-quarters of the studies evaluate scenarios for transportation impacts; more than half for impacts on open space and resource lands; 33 for impacts on criterion air pollutants; 18 for impacts on fuel use; and ten for greenhouse gas emissions (Bartholomew 2005).

A subset of 23 studies was selected for this publication, based on three criteria: simulations conducted at the regional scale, consistent population and employment totals across the scenarios, and availability of data for all scenarios on density, population growth, and VMT. Together, these studies tested a total of 85 regional development scenarios—one trend scenario per study, plus 62 planning scenarios that could be compared to trend.

### 3.3.5 Differences across Scenarios

The percentage difference in regional VMT for each planning scenario, relative to its respective trend scenario, is shown in Figure 3-19. Each bar represents a different planning scenario; the value shown is the percentage difference between that scenario and the study's trend scenario. Across studies, the median reduction in regional VMT is 5.7 percent, none too impressive. However, there is wide variation in values across scenarios, from + 5.2 percent to –31.7 percent, which suggests that regional growth patterns may have a substantial impact in the best case scenario.

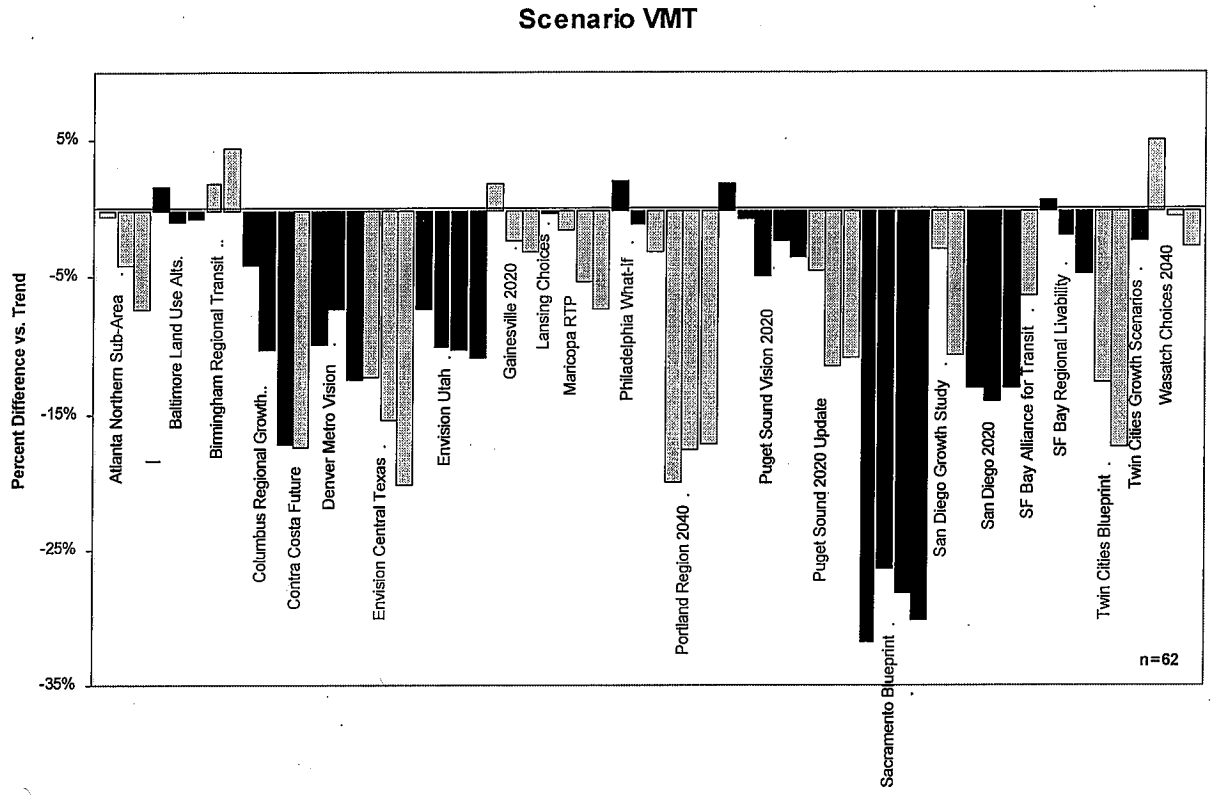
Why is there so much difference in VMT across scenarios? Bartholomew identifies many of the potential sources of variation that could be considered in a meta-analysis. These, with their presumed impact on VMT, include the following:

- nature of the scenarios (denser, more mixed, and more centered ones result in bigger VMT reductions);
- planning time horizon (longer horizons result in bigger VMT reductions);
- rate of growth (more growth that can be redirected results in bigger VMT reductions);
- reallocation of transportation dollars (higher transit investments result in bigger VMT reductions); and
- addition of travel demand management strategies (higher costs of automobile travel result in bigger VMT reductions).

While a few planning scenarios are more dispersed than trend, the great majority are more compact (see Figure 3-20). The median increase in regional density of planning scenarios over trend is 13.8 percent. Here, again, there is wide variation across scenarios, from a 14.8 percent lower density for the most dispersed scenario to a 64.3 percent higher density for the most compact scenario.

The two variables are plotted against one another in Figure 3-21. As anticipated, this simple scatter plot shows that higher scenario densities are associated with greater VMT reductions relative to the trend. The relationship appears strong and linear.

**Figure 3-19 VMT Differences for 62 Scenarios Relative to the Trend Scenario***
*Source: Bartholomew 2005.*




*Additional information about most of these projects is available through a digital library on scenario planning maintained by the University of Utah (http://www.lib.utah.edu/digital/collections/highways/).

**Figure 3-20 Scenario Densities for 62 Planning Scenarios Relative to the Trend Scenario**
*Source: Bartholomew 2005.*

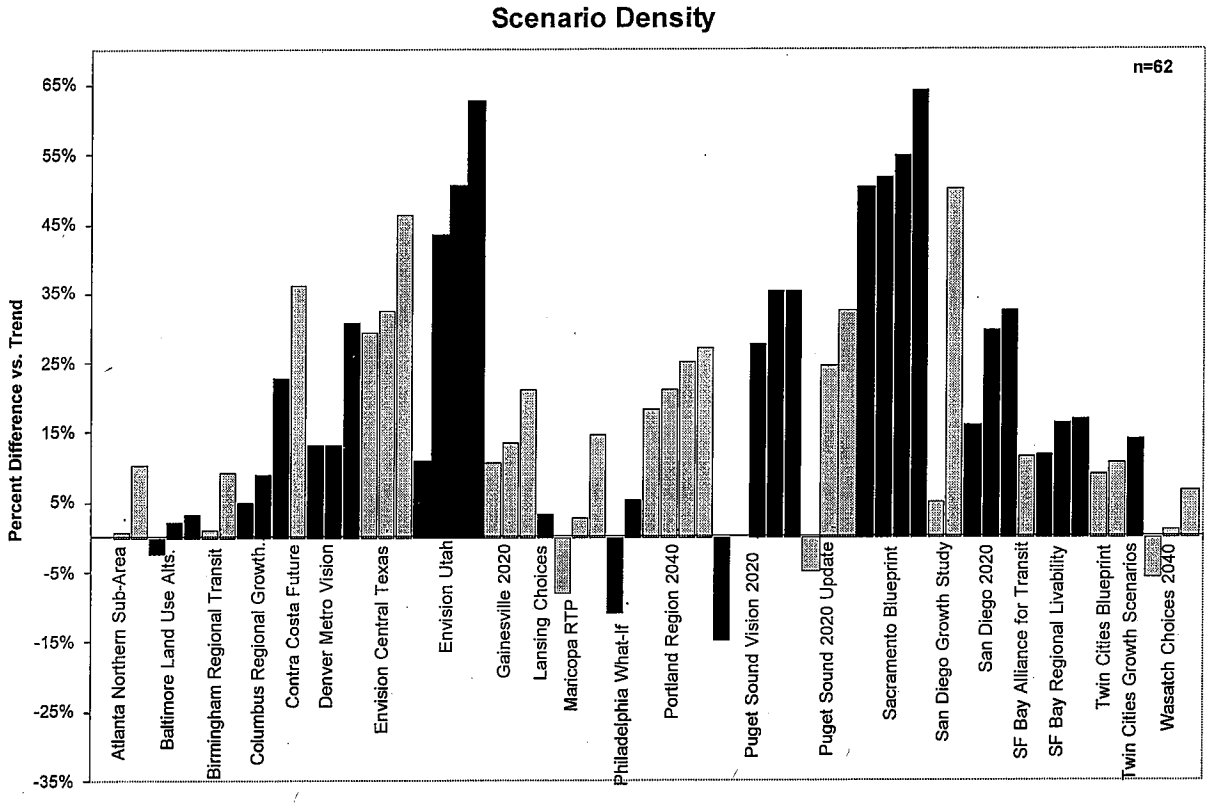
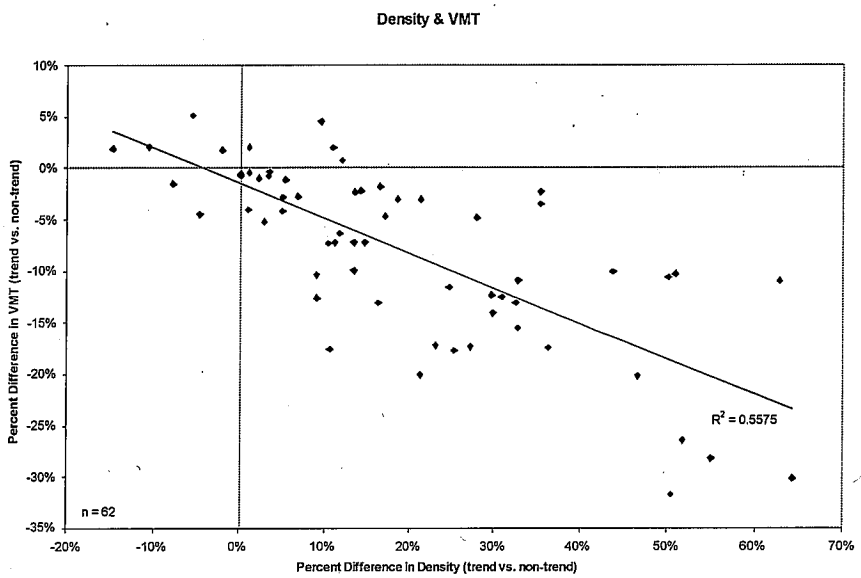
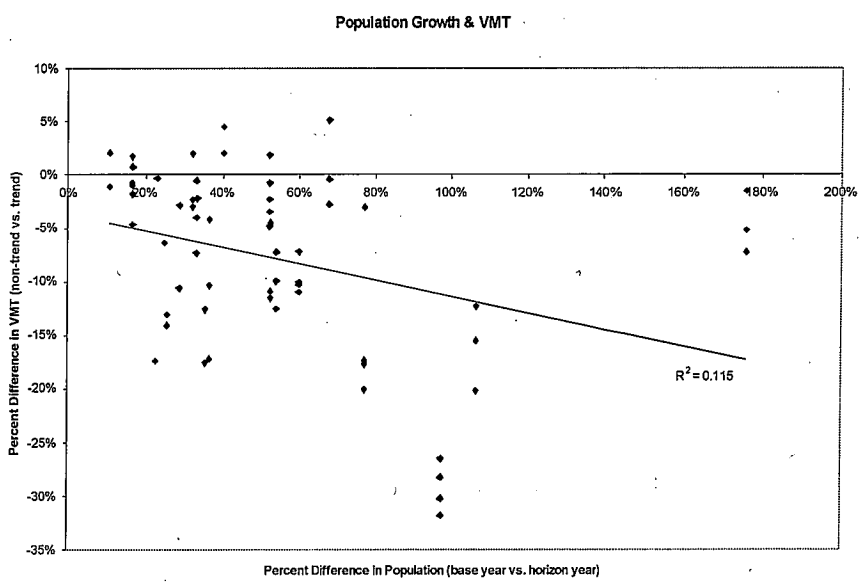


**Figure 3-21 VMT versus Density for 62 Planning Scenarios Relative to the Trend**
*Source: Bartholomew 2005.*




While much VMT reduction may be accounted for by higher densities, the scatter around the regression line in Figure 3.21 suggests that other factors also are at work. Figure 3-22 plots the percent difference in VMT for each planning scenario relative to trend against the percent population growth during the planning period for the metropolitan region as a whole (from base year to target year). Again, a correlation is apparent. The greater the increment of population growth that can be redirected in a planning scenario, the greater the difference in VMT. The growth increment is a function of both planning horizon (the further out, the more growth can be reallocated) and growth rate (the higher the growth rate, the more growth can be reallocated).

**Figure 3-22 Percent Difference in VMT versus Percent Increase in Population for Planning Scenarios Relative to the Trend**
*Source: Bartholomew 2005.*




Other variables may contribute to VMT changes as well. Several were represented by dummy variables in this meta-analysis. A dummy variable is a variable that assumes a value of one or zero, depending upon whether a condition is met. Dummies are regularly used to represent categorical variables in analyses such as this.

Lacking numeric data on these variables, we relied on narrative descriptions of scenarios in study documents to create dummy variables. For example, one dummy variable was used to distinguish between scenarios that mix and balance residential and commercial land uses to a high degree (assigned a value of one), and scenarios that mix and balance land uses only to the same degree as in trend development (assigned a value of zero). Some of the dummies were specific to scenarios; others were specific to regions and/or studies.

### 3.3.6 Meta-Analysis of Regional Simulation Studies

With so many independent variables, it becomes hard to discern relationships from simple scatter plots. This is a multivariate problem that requires a multivariate analysis to isolate the effect of each independent variable on the dependent variable, holding the other variables constant.

The analysis is further complicated by the multilevel nature of the data structure. Scenarios are "nested" within regions, with the typical region having two or three alternatives to the trend. Scenarios for the same region are not independent of each other, as they share the characteristics of their respective regions. Thus, standard (ordinary least squares) regression analysis cannot be used to analyze this multivariate data set. Rather, a hierarchical or multilevel modeling technique is required.[23]

A hierarchical linear model was estimated for the continuous outcome, percent difference in VMT relative to trend. Independent variables tested were at two levels, those specific to scenarios and those specific to studies (the latter common to all scenarios for a given region). Independent variables specific to scenarios were as follow:

- percent difference in gross density relative to trend development (–15 percent to +64 percent);
- development centralized/infill emphasized (one if yes, zero if no); and
- land uses highly mixed (one if yes, zero if no).

Independent variables common to scenarios for a given region but different across regions/studies are as follow:

- percent population growth increment relative base population (10 percent to 176 percent);
- auto use priced higher (one if yes, zero if no); and
- transportation investments coordinated with land uses (one if yes, zero if no).

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[23] For region-level characteristics, ordinary least squares (OLS) regression analysis would underestimate standard errors of regression coefficients and would produce inefficient regression coefficient estimates. Hierarchical modeling overcomes these limitations, accounting for the dependence of scenarios for the same region and producing more accurate regression coefficient and standard error estimates (Raudenbush and Byrk 2002). Within a hierarchical model, each level in the data structure is represented by its own submodel. Each submodel captures the structural relations occurring at that level and the residual variability at that level. To represent such complex data structures, this study relied on HLM 6 (Hierarchical Linear and Nonlinear Modeling) software.

The best-fit model is presented in Figure 3-23. For theoretical reasons, the model was estimated with no constant term (as a regression through the origin). If nothing changes from trend, there should be no reduction in regional VMT. There are three significant influences on VMT: the population growth increment, centralized development, and mixed land use. All three are associated with decreases in VMT relative to trend. The increase in density relative to trend has the expected sign but falls just short of significance. Coordinated transportation investment also has the expected sign but is not significant.

The elasticity of VMT with respect to the population growth is –0.068, meaning that there is a 0.068 percent decrease in VMT per capita for every 1 percent increase in population relative to the base year. This does not argue for population growth per se, but simply indicates that regions that are growing rapidly have more opportunity to evolve toward a compact urban form than regions that are growing slowly.

Centralization of regional development and mixing of land uses both are inversely related to VMT at the 0.05 probability level. From their coefficients, we would expect a 1.5 percent drop in regional VMT with centralized development, and a 4.6 percent drop in regional VMT with mixed-use development (after controlling for other variables).

While the regional density variable is not statistically significant, our best guess at the elasticity of VMT with respect to regional density is –0.075, meaning that there would be a 0.075 percent decrease in VMT for every 1 percent increase in population density. This is a little higher than the elasticity estimate from the disaggregate travel studies in section 3.2. The density variable likely is soaking up some of the effect of other D variables that are not adequately represented in the regional growth simulations.

The coordinated transportation investment variable also is not statistically significant. Again, our best estimate of the impact of coordinated transportation investments, controlling for other variables, is a 2.1 percent reduction in regional VMT.

When forced into the model, the imposition of transportation pricing policies has a positive coefficient, suggesting that it would lead to higher VMT. This counterintuitive result is discussed in section 3.3.9.

Plugging realistic numbers into the best-fit model in Figure 3-23, we can estimate the VMT reduction associated with a shift to compact development. If such a shift increases average regional density by 50 percent in 2050, emphasizes infill, mixes land uses to a high degree, and has coordinated transportation investments, it would be expected to reduce regional VMT by about 18 percent over 43 years at an average metropolitan growth rate of 1.3 percent annually.[24]

[24] Computed as –0.074*50 – 1.50*1 – 4.64*1 – 0.068*73 – 2.12*1. The 73 in the preceding formula represents a growth increment of 73 percent, or 43 years at an average growth rate of just over 1.28 percent per year.

**Figure 3-23 Best-Fit Model of Percent VMT Reduction Relative to Trend (with Robust Standard Errors)**

| | Coefficient | t | P |
|---|---|---|---|
| Difference in density (% above trend) | –0.074 | –1.48 | 0.15 |
| Development centralized | –1.50 | –2.13 | 0.037 |
| Land uses mixed | –4.64 | –2.15 | 0.036 |
| Population growth increment (% over base) | –0.068 | –2.02 | 0.056 |
| Transportation coordinated | –2.12 | –1.01 | 0.33 |

### 3.3.7 The Conservative Nature of Scenario Forecasts

This forecasted reduction in regional VMT with compact development is almost surely an underestimate due to limitations of the travel demand models used in these studies. It is widely known, and oft-stated, that conventional regional travel models of the type used in most regional scenario studies are not sensitive to the effects of the first three Ds—density, diversity, and design (Walters, Ewing, and Allen 2000; Johnston 2004; Cervero 2006; DKS Associates and University of California 2007; Beimborn, Kennedy, and Schaefer undated). Conventional models can simulate land use and transportation system effects on travel at the gross scale of a region, but not at the fine scale of a neighborhood. In particular, they cannot account for the micromixing of land uses, interconnection of local streets, or human-scaled urban design. Most do not even consider walk or bike trips, adjust vehicle trip rates for car shedding at higher densities, or estimate internal trips within mixed-use developments.[25]

[25] What is missing from conventional travel demand models are five D variables. The following is true of nearly all conventional four-step models: 1) Only trips by vehicle are modeled, and trip rates are related only to characteristics of people, not characteristics of place. The possibility of households in urban settings making fewer vehicle trips—and instead using nonmotorized modes—is not considered. 2) Households, jobs, and other trip generators are assumed to be located at a single point, the zone centroid, and the entire local street network is reduced to one or more centroid connectors to the regional street network. This precludes the modeling of intrazonal travel in terms of the local built environment. 3) The choice between transit and auto modes is modeled solely in terms of characteristics of travelers and modes. The characteristics of origins and destinations—their transit-friendliness and walkability—are disregarded. 4) Trips are treated as unlinked, when a majority of trips nowadays are part of tours (trip chains) in which each trip depends on the trips preceding and following it, in a linked fashion. Destinations doubtless are chosen based not only on the attractions they contain, but also based on their accessibility to other trip attractions. 5) Trip attractions are summed for component land uses in a given zone, with each use treated as independent of the others. Yet mixed-use development is known to generate fewer vehicle trips than the component uses individually. 6) Daily travel is allocated to the peak hour based on fixed factors, disregarding the tendency for peak spreading when land uses become concentrated enough to produce serious peak-hour congestion. Peak spreading is the rescheduling of trips from the peak hour to the shoulders of the peak.

These failings and others have prompted:

- the U.S. Department of Transportation to spend millions of dollars developing a new generation of travel demand models under the Travel Model Improvement Program;
- the U.S. EPA to develop the Smart Growth Index model;
- leading MPOs such as Portland Metro (for the LUTRAQ study) to enhance their conventional "four-step" models with additional steps and feedback loops; and
- other leading MPOs to post-process model outputs or develop direct transit ridership models.

How much additional VMT reduction might be achieved with compact development, beyond that forecasted in regional growth simulations? To a first approximation, we can think of conventional travel models as accounting for one of the D variables, destination accessibility. The effects of the other D variables, outlined in section 3.2, are largely neglected. Were they factored into the analyses, one could easily reach VMT reductions of 20 percent or more.

### 3.3.8 Regional Growth and Vehicle Emissions

Our sample of regional growth studies is not large enough, and the studies themselves are not sophisticated enough, to support meta-analyses of impacts of smart growth on other outcomes (beyond VMT). At most, they support qualitative statements and inferences.

Vehicle emissions, including $CO_2$, are not merely a function of VMT, but also reflect the numbers of cold starts plus vehicle operating speeds (see section 2.3). Figure 3-24 shows that for many scenarios, an increase in density is associated with a drop in average peak hour operating speeds—an outcome that could result in increased emissions because gasoline engines function more efficiently at higher speeds.

**Figure 3-24 Percent Differences in Peak Hour Average Speed versus Density for Planning Scenarios Relative to Trend**

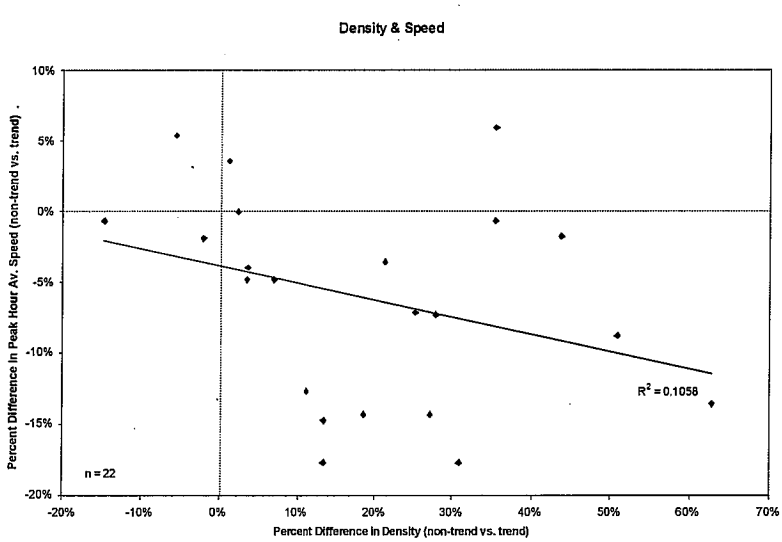


**Figure 3-25. Percent Difference in NOx Emissions versus Percent Difference in Density for Planning Scenarios Relative to the Trend**

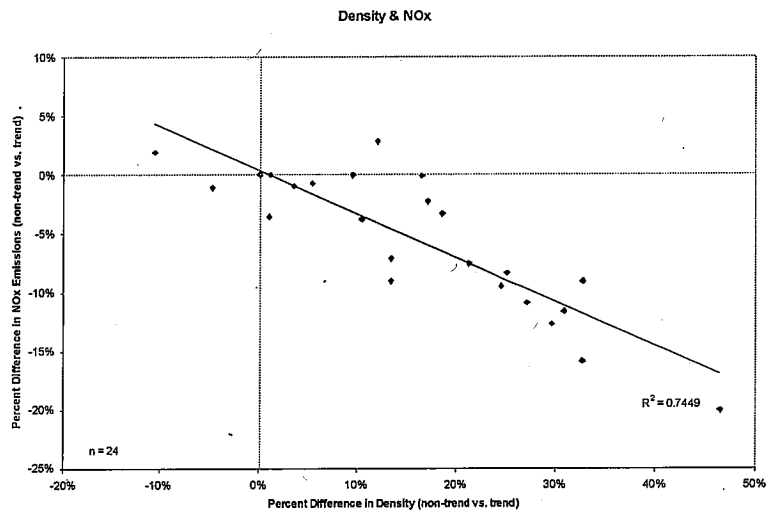
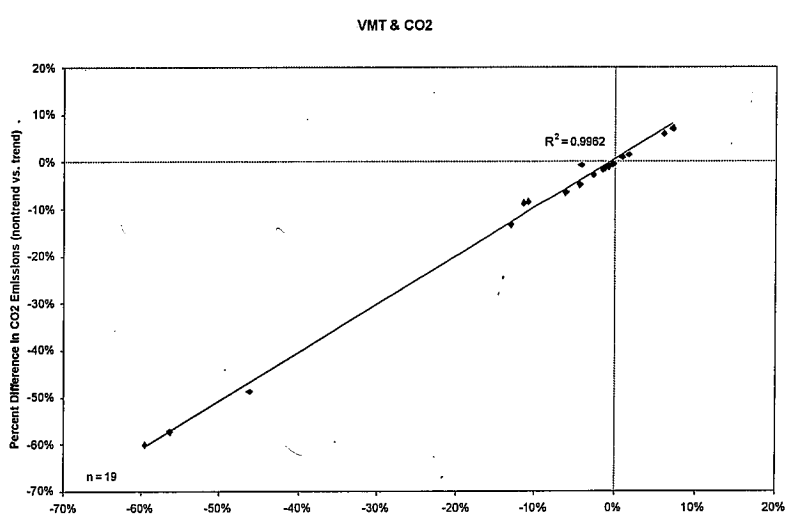



Figure 3-25 plots nitrogen oxide (NOx) emissions versus density differences for 24 planning scenarios. The scatter plot shows a strong association between the two variables. The strength of the association appears equivalent to that between VMT and density. Because most or all of these studies use vehicle emission models that account for differences in vehicle operating speeds, we can reasonably conclude from these data that any effect of density on emissions through vehicle operating speeds is overwhelmed by the effect of density on emissions through VMT. As with the observations above on energy consumption and speed (Figure 3-4), compact development is associated with lower emissions, notwithstanding possible reductions in vehicle speeds.

Data on regional $CO_2$ emissions are more limited. The scarcity of the forecasts indicates that the agencies undertaking scenario planning studies—primarily MPOs—have not focused on carbon emissions as a planning issue. Figure 3-26 plots VMT versus $CO_2$ differences for 19 planning scenarios. The near-perfect correlation and the elasticity value close to 1.0 suggest the multiplication of VMT by some constant factor to arrive at $CO_2$ forecasts.

**Figure 3-26 Percent Difference in VMT and $CO_2$ Emissions for Planning Scenarios Relative to Trend**



### 3.3.9 Regional Growth and Transportation Pricing

The meta-analysis in section 3.3.6 produced one anomalous result. When forced into the model, the imposition of transportation pricing policies has a positive coefficient, suggesting that it would lead to higher VMT. This is probably explained by confounding variables and the small sample of studies that actually test pricing policies.

In theory, the impact of pricing schemes on land development patterns could be positive or negative, depending on the pricing scheme. Increasing the price of driving (roads or parking) in only one part of a metropolitan region or along only a limited number of corridors could shift future economic and development activity away from the priced area or corridors and toward areas that are unpriced (Deakin et al. 1996). This could increase overall driving and VMT. Using an areawide pricing approach, however, could result in a concentration of future growth. This would occur as households and businesses seek to reduce or avoid the extra costs (Komanoff 1997). Some simulation-based evidence supports this conclusion (Gupta, Kalmanje, and Kockelman 2006).

If transportation pricing is ultimately adopted as a strategy to reduce VMT and $CO_2$, compact development could prove useful in both cushioning the blow to household budgets and enhancing the travel reduction effects (see Cambridge Systematics 1994). The LUTRAQ project, which was not included in the meta-analysis, provides data that support this conclusion. The project compared three scenarios: 1) a trend scenario that assumed the continuation of recent development practices and transportation investments, including a new highway; 2) the same scenario with an areawide parking pricing/free transit pass policy added;[26] and 3) a transit-oriented development scenario (LUTRAQ) with two additional rail lines and the same parking/transit pass component. Adding the LUTRAQ land use/transit element to the pricing/subsidy package tripled reductions in NOx and nearly quadrupled reductions in VMT and $CO_2$ emissions (see Figure 3-27).

**Figure 3-27 Percentage Reduction in Transportation Outcomes with Transportation Pricing, and Pricing and Compact Development Combined**
*Source: 1000 Friends of Oregon 1996.*

| | Pricing/Subsidy | LUTRAQ w/ Pricing/Subsidy |
|---|---|---|
| Daily VMT | – 2% | – 7.9% |
| NOx Emissions (kg/day) | – 2.9% | – 8.7% |
| $CO_2$ Emissions (kg/day) | – 2% | – 7.9% |

[26] The pricing policy assumed an areawide $3.00 per day parking charge for drive-alone work trips. The income was used to provide free transit passes to all commuters in the study area.

## *3.4 Project-Level Simulations*

We also can assess the effects of the built environment through comparisons of VMT and vehicle emissions generated by individual land developments. These comparisons may be based on actual travel diaries or odometer readings for residents of existing developments. Or they may be based on simulations using conventional travel models calibrated and validated for the study region and, in some cases, enhanced to capture the effects of localized variations in density, diversity, and design.

Unlike regional scenario studies, project-level simulations have the advantage of focusing on the subset of the regional population for whom the built environment actually varies. Site plans can vary in density, diversity, or design, without differences in regional location or proximity to transit. Regional location can vary from transit-served brownfields to auto-only greenfields, without any difference in site plans. Or both can vary. The amount of development (housing and employment) generally is held constant in project-level simulations, but acreage may differ across site plans.

### 3.4.1 Case Study: Atlantic Steel Project XL

The 1999 study of the Atlantic Steel project—now known as Atlantic Station—is a prominent example of project-level simulation with both types of variation. The redevelopment project is on a 138-acre former steel mill and brownfield site in Midtown Atlanta. A developer proposed converting the vacant site into a "new town in town." Its location—close to primary regional destinations and to rapid transit—and its dense, mixed-use design made the proposed Atlantic Steel redevelopment a classic smart growth infill project, favored by everyone from the city's mayor to the vice president of the United States (at the time, Al Gore).

The dilemma was that the redevelopment project required a bridge over Interstate 75/85 to connect to a rapid transit station and a neighborhood to the east, plus ramps for access to the interstate highways. At the time, the Atlanta region was out of compliance with federal transportation conformity requirements and, as a result, could not tap into federal funds to add to its highway system. It could not even construct certain highway improvements using nonfederal funds. The proposed bridge and ramps were included in this prohibition.

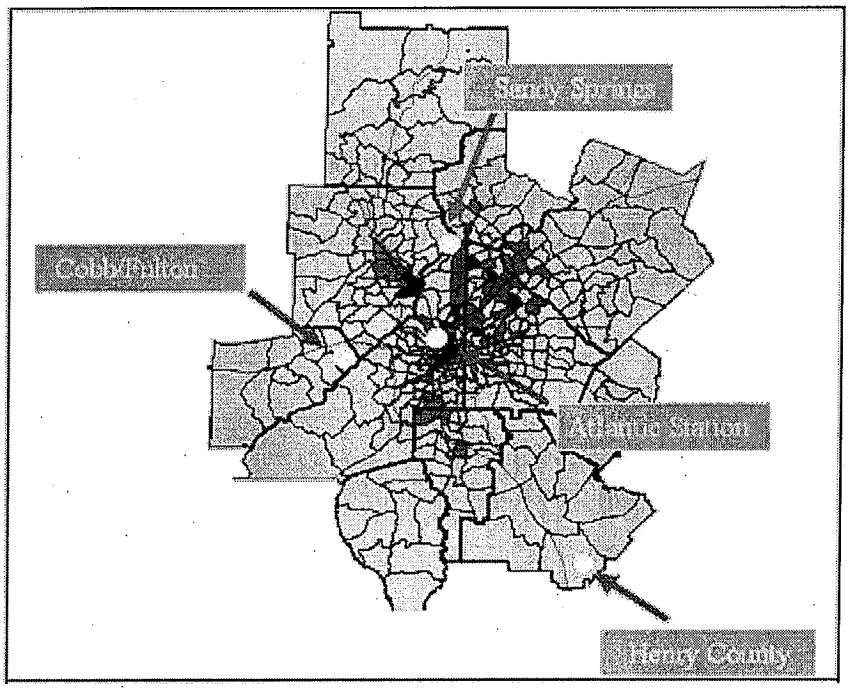
Under a program called Project XL (excellence and leadership), the EPA has the power to waive environmental regulations when a superior environmental outcome may be achieved by some otherwise prohibited action. Based on an analysis showing that redevelopment of the Atlantic Steel site would produce less VMT and vehicle emissions than development of likely alternative sites in outlying areas, the EPA ultimately waived the conformity requirement for this project.

For this analysis, a team of consultants evaluated the Atlantic Steel project from two standpoints:

- *Regional location.* The Midtown site was compared to three greenfield sites large enough to accommodate the proposed development. The sites were at increasing distances from the urban core: a perimeter beltway location, a suburban location, and an exurban location, each with a development density and site plan typical of its location. The map below shows the location of the Atlantic Steel site and the three greenfield sites relative to the urban core.

- *Site plan.* Three alternative plans for the Atlantic Steel site—incorporating different intrasite densities, land use mixes, street networks, and streetscape design elements—were compared. They were the Jacoby Development Corporation's original site plan, an "improved new urbanism case" developed through a charrette process by Duany Plater-Zyberk & Company (DPZ), and a final compromise plan incorporating key DPZ concepts.

The original Jacoby design mixed land uses primarily on the site's east side, nearest the MARTA rapid transit station. On the west side, the developer proposed a single-use office park with buildings set back from the street and separated by stretches of undeveloped green area and parking. Residences were located between the office park and the retail/hotel district. The street network was an adaptation of the site's existing grid system, with some connections to neighborhood streets to the south.




**Alternative regional locations evaluated.**
*Based on EPA (1999)*

With everything riding on EPA approval, the agency had the leverage to push for a more integrated site plan. The DPZ plan, generated at a design charrette, mixed land uses within the site to a great degree, while holding the amount of office, retail, and residential development constant. Only the far west side retained the single-use character of the original site plan, in an office district. The redesign featured shorter blocks, narrower streets, improved streetscapes, and clear pedestrian paths. Auto speeds were controlled to provide a better pedestrian environment. Densities were increased near transit stops. The street grid of the surrounding neighborhood was extended into the site, and land uses were moved to permit shared parking.

Jacoby's final site plan is a compromise between the two earlier plans. The land use mix is more fine-grained than the original plan's but not as fine-grained as the DPZ redesign. The street network is more fine-meshed than the original plan's but less so than the redesign. Other concepts from the DPZ charrette, and from the literature on the built environment and travel, have been retained.

**Alternative site plans evaluated**
*Based on EPA (1999)*

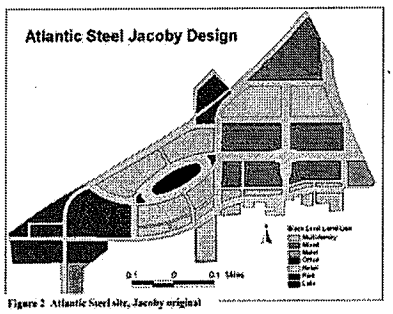


Figure 2 Atlantic Steel site, Jacoby original

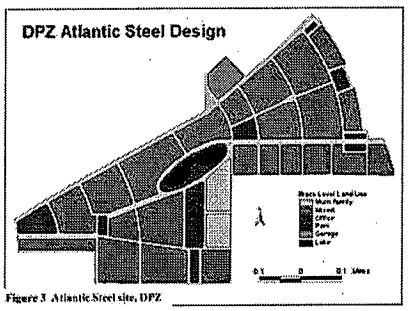


Figure 3 Atlantic Steel site, DPZ

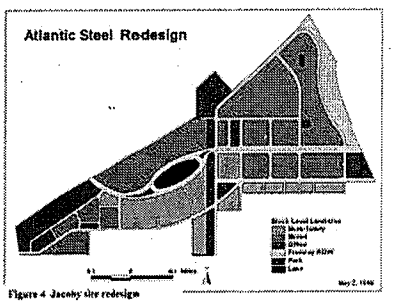
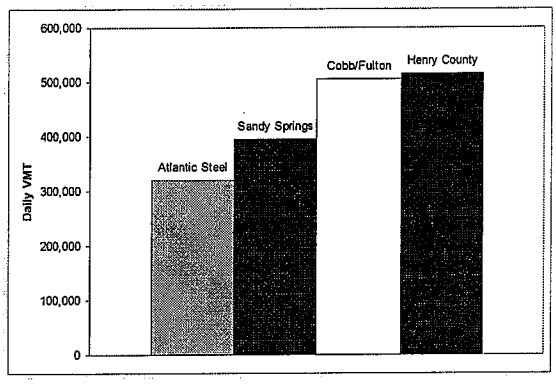


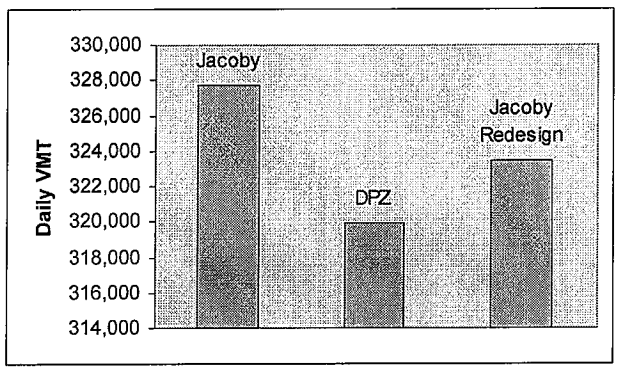
Figure 4 Jacoby site redesign

First, the EPA consultant team performed an in-depth evaluation of travel forecasting methods used in the Atlanta region. The evaluation resulted in various refinements to the Atlanta Regional Commission's conventional travel forecasting model to better account for regional location and destination accessibility, and in postprocessing of model outputs to better account for the first three Ds—density, diversity (mix), and design (Walters, Ewing, and Allen 2000). Postprocessing employed an early version of the Smart Growth Index model with elasticities derived from a review of recent research on the built environment and household travel (as described in section 3.2).

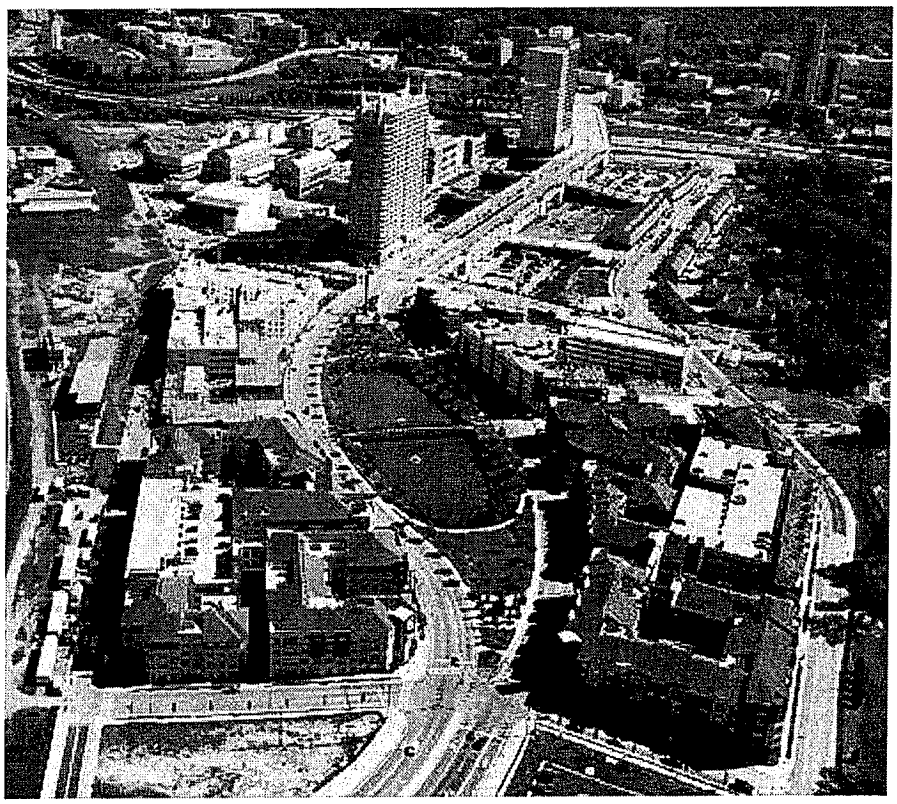
Model results demonstrated that VMT and emissions would be about 30 percent lower at the Atlantic Steel infill site than at the remote greenfield locations, and an additional 5 percent lower with the revised site plan (see Figure 3-28). As a result, for the first time, the EPA designated a land development proposal as a regional transportation control measure, allowing for approval of the project and funding of transportation Aimprovements. Atlantic Station has become a highly successful, largely built and occupied, infill community (see photographs below).

**Figure 3-28 VMT Generated by Regional Location and Site Plan Alternatives**
*Source: EPA 1999.*




**Atlantic Station today.**

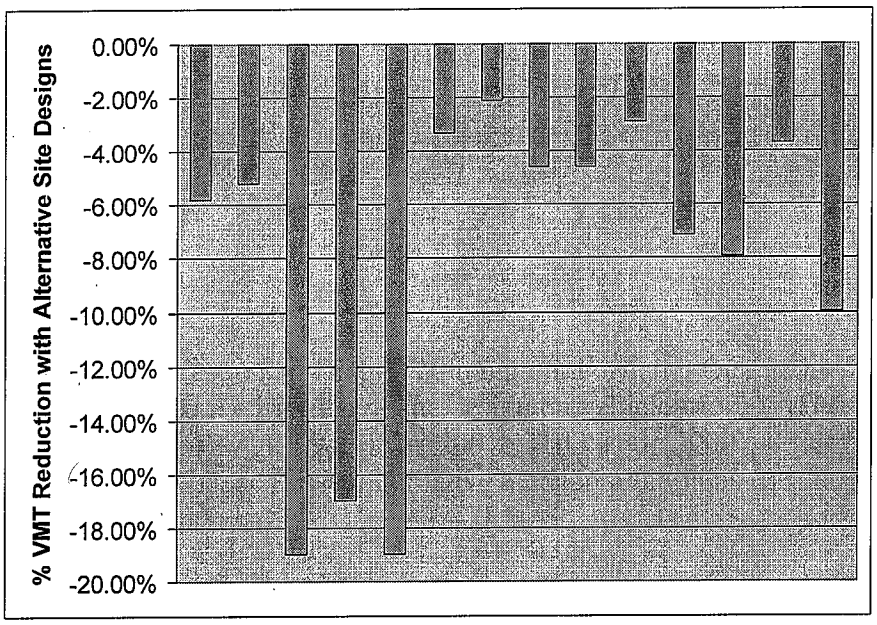


*Source: Jacoby Development Company*

### 3.4.2 Site Plan Influences on VMT

The Atlantic Steel study—and similar studies in San Diego, Wilmington, Portland, Oak Ridge, San Antonio, and Toronto—have forecasted the impacts of site design on vehicle trips, VMT, and/or $CO_2$ emissions (Hagler Bailly 1998; EPA 1999, 2001a, 2001b; IBI Group 2000). Figure 3-29 presents the findings of these studies. In each case, alternative development plans for the same site are compared to a baseline or trend plan.

**Figure 3-29 Effect of Site Design Alone on VMT**

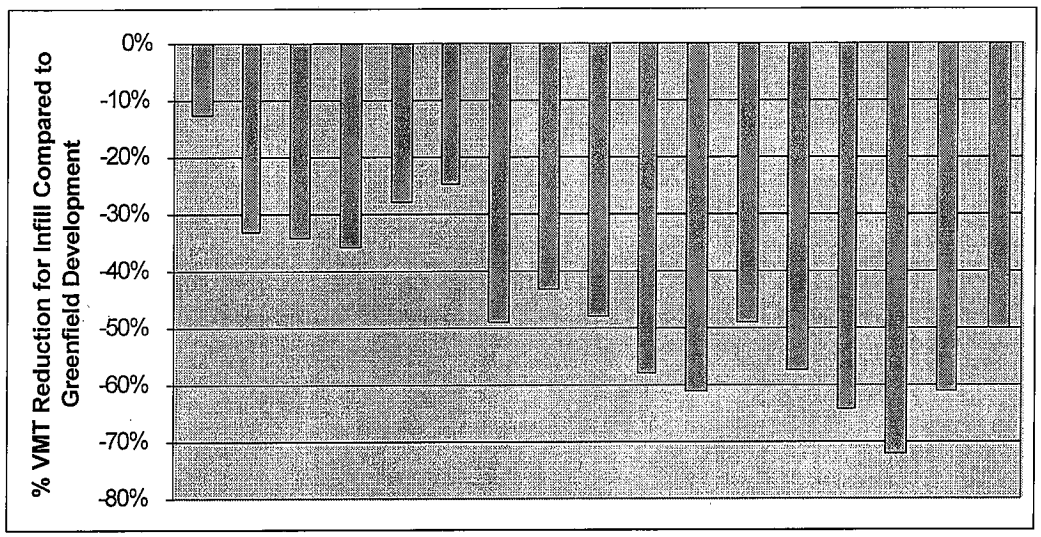



Results suggest that VMT and $CO_2$ per capita decline as site density increases and the mix of jobs, housing, and retail uses becomes more balanced. However, the limited number of studies, differences in assumptions and methodologies from study to study, and the variability of results make it difficult to generalize.

### 3.4.3 Regional Location Influences on VMT

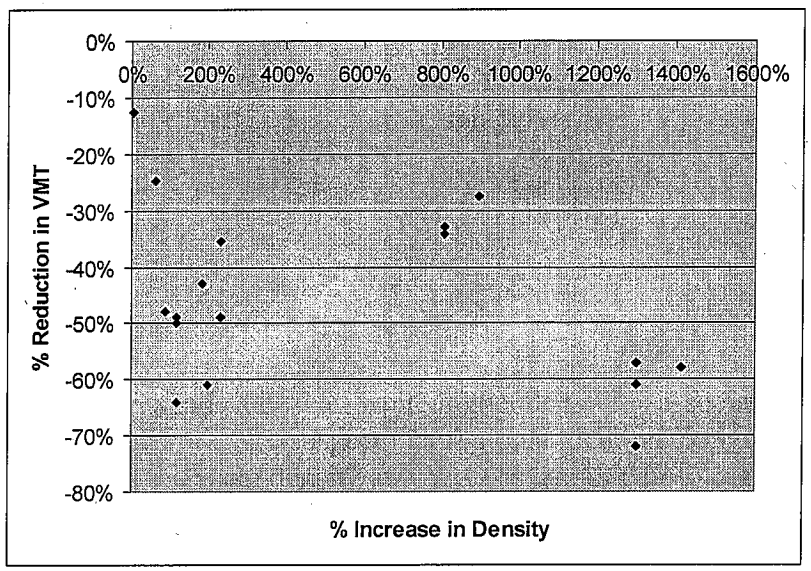
Approximately ten studies have considered the effects of regional location on travel and emissions generated by individual developments (EPA 1999, 2001a, 2001b, 2006; Hagler Bailly 1998; Hagler Bailly and Criterion Planners/Engineers 1999; IBI Group 2000; Allen and Benfield 2003; U.S. Conference of Mayors 2001). The studies differ in methodology and context, and in some cases include changes in site design. But they tend to yield the same conclusion: infill locations generate substantially lower VMT per capita than do greenfield locations, from 13 to 72 percent lower (see Figure 3-30).

**Figure 3-30 Effect of Regional Location and Site Design on VMT**




In Figure 3-31, the distribution of data points indicates that, while higher density is associated with reduced VMT, other factors also are at work. We suspect that regional location explains most of the scatter, and that the relationship between density and VMT is due in part to regional location as well. The highest densities are programmed for the most central locations.

**Figure 3-31 Relationship between Density Increase and VMT Reduction**

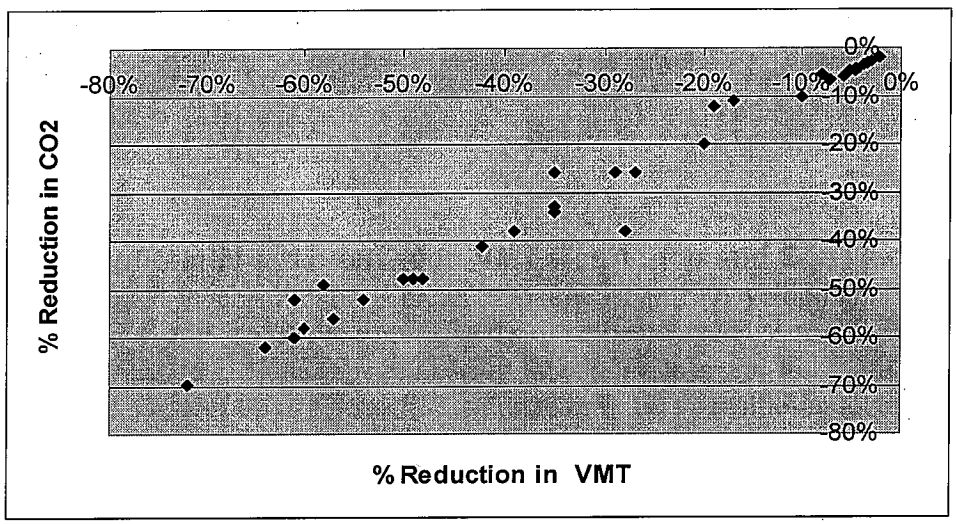



The data from project-level simulations are too limited to conduct a true meta-analysis of the variance in VMT per capita. However, the data clearly suggest that development that combines an infill location with higher density and good urban design can produce dramatic VMT reductions compared to typical greenfield development. VMT reductions cluster between about 30 and 60 percent. When compared with the results of the site design studies, which show VMT reductions of 2 to 19 percent, the effect of regional location appears much stronger than that of project density and site design alone.

### 3.4.4 The Relationship between VMT Reduction and $CO_2$ Reduction

These project-level simulations indicate that dense infill developments also are associated with reduced $CO_2$ emissions (see Figure 3-32). On a percentage basis, $CO_2$ reductions are not quite as large as VMT reductions. The regression line suggests an elasticity of $CO_2$ emissions with respect to VMT of 0.96. This is likely due to emission penalties associated with reduced vehicle operating speeds at infill locations.

**Figure 3-32 Reduction in $CO_2$ Emissions versus Reduction in VMT**



# 4. Environmental Determinism versus Self Selection

There is a long-running debate in urban planning about the degree to which the physical environment determines human behavior. The theory of environmental or architectural determinism ascribes great importance to the physical environment as a shaper of behavior. The counter view is that social and economic factors are the main or even exclusive determinants of behavior.

To outsiders, this debate may seem simplistic. Any extreme view would be. Yet, we all bring paradigms to the study of travel behavior, paradigms that affect our interpretation of the facts. Depending on one's point of view, the documented relationship between the built environment and travel might just as well be due to 1) individuals who want to walk or use transit selecting pedestrian- or transit-friendly environments (self selection) as it is to 2) pedestrian- and transit-friendly environments causing individuals to use these modes of travel more than they would otherwise (environmental determinism).

For many of the studies reviewed in Chapter 3, we can discount self selection because the unit of geographic analysis is the region or county. Travel preferences likely fall far down the list of factors—after job access, climate, cost-of-living, and family ties—that people consider when choosing a region or county in which to live. For those moving from one neighborhood to another, however, a desire to walk or use transit could be a factor in their decision, a possibility to which we now turn our attention.

## *4.1 The Empirical Literature on Self Selection*

Does residential choice come first, and travel choice or some other outcome follow (environmental determinism)? Or do people's propensities for travel and physical activity determine their choice of residential environment (self selection)? Between environment and attitude, which drives behavior?

More than anything else recently, the possibility of self-selection bias has engendered doubt about the travel benefits of compact urban development patterns. According to a Transportation Research Board/Institute of Medicine report (2005), "If researchers do not properly account for the choice of neighborhood, their empirical results will be biased in the sense that features of the built environment may appear to influence activity more than they in fact do. (Indeed, this single potential source of statistical bias casts doubt on the majority of studies on the topic to date.)"

Self selection occurs if the choice of residence depends in a significant way on attitudes about, or preferences for, one mode of transportation over another. In the language of research, such attitudes will confound the relationship between residential environment and travel choices. Most of the "evidence" for or against self selection is circumstantial.

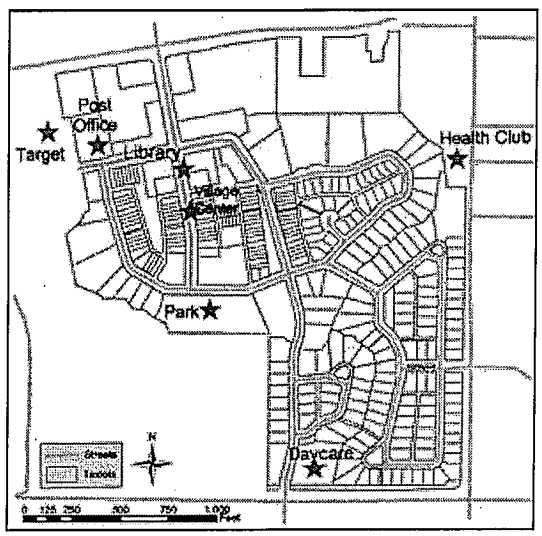
Many studies have cited associations between attitudes and travel choices as evidence of self selection. Favorable attitudes about walking correlate with walking; favorable attitudes about the environment correlate with transit use. It would be surprising, indeed, if travelers who are favorably disposed toward a given mode did not use that mode more frequently than others,

regardless of where they live. But this does not mean that attitudes account for the observed relationship between the built environment and travel. For self selection to occur, attitudes must also influence residential choices.

Planning researchers frequently ask new residents whether transit accessibility, walkability, or access to specific destinations were factors in their location decisions. Access considerations usually fall well down the list of location factors, after housing price and quality, neighborhood amenities, and school quality.

Typical of such surveys is one by Dill (2004). Fairview Village is a mixed-use, new urbanist neighborhood in suburban Portland, Oregon, with interconnected streets and attractive streetscapes (see the photograph and site plan below). Residents were asked to rate the importance of location factors in choosing their new home. The highest-rated factors were neighborhood safety, neighborhood style, and house price. Among access variables, "quick access to the freeway" was ranked highest at number eight. Pedestrian access ranked lower. "Having stores within walking distance" was 12th in importance, and "having a library within walking distance" was 14th. Still, pedestrian access was rated as more important in Fairview Village than in two nearby subdivisions matched for income, home value, home size, and year built. Apparently, self selection is present but weak. Whatever the underlying cause, attitude, or environment, walk trips are much more frequent in Fairview Village, and VMT per adult is 20 percent lower than in otherwise comparable suburban subdivisions (see Figure 4-1).

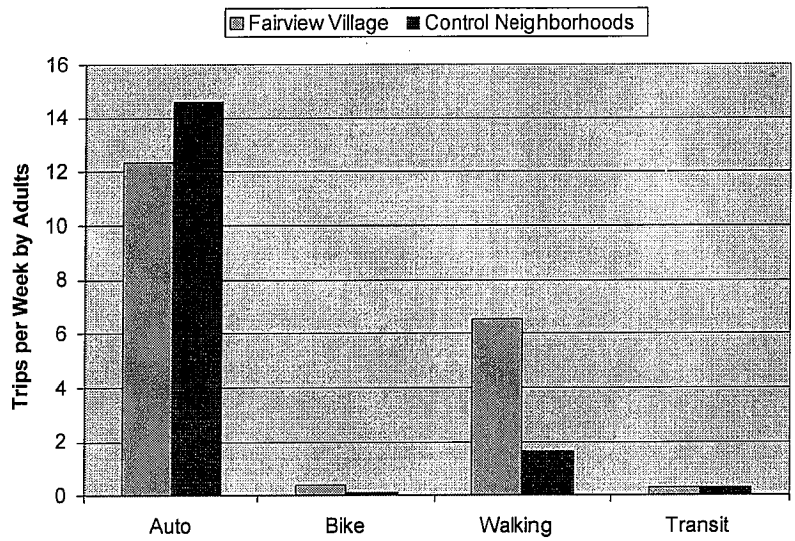
**Fairview Village City Hall and nearby housing.**




**Fairview Village site plan.**
*Source: Rose 2004*

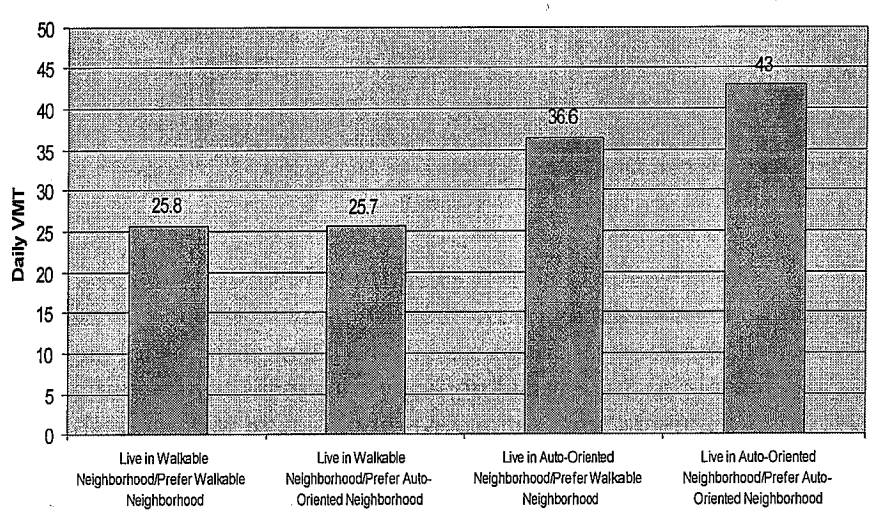
**Figure 4-1 Number of Trips by Mode and by Neighborhood***
*Source: Based on data in Dill 2004.*

*By adults, per week.




The strongest survey-based evidence of self selection is Lund's (2006) study of people who had recently moved to transit-oriented developments (TODs) on rail lines in California. For TOD residents, transit access ranked third among location factors in San Francisco and fifth in Los Angeles and San Diego (where, amazingly, it ranked lower than highway access). One-third of all respondents mentioned transit access as one of the top three reasons for locating in a TOD. These residents were much more likely to use transit than those not citing transit access as a location factor. Yet, because the survey did not collect comparable data on prior travel mode, we cannot draw any inference regarding the strength of attitudes versus environment or on the effect of transit-oriented development on net regional transit use.

**Figure 4-2 Average VMT by Neighborhood Type and Residential Preference**
*Source: Frank et al. forthcoming.*




The strongest survey-based evidence of environmental determinism is Frank et al.'s (forthcoming) in-depth study of 8,000 households in Atlanta, which indicates that the built environment and availability of alternatives can lead anyone, regardless of preference, to drive less. Just comparing those who stated a preference for walkable environments, VMT was 40 percent lower among those who actually lived in a walkable neighborhood than among those who lived in an auto-oriented neighborhood (see Figure 4-2). Roughly one in three current residents of automobile-oriented neighborhoods would prefer to live in a walkable environment but were unable to find one, given current development patterns. This alone indicates a ready-made market for compact development.

At least 28 studies using different research designs have attempted to test and control for residential self selection (Mokhtarian and Cao forthcoming; Cao, Mokhtarian, and Handy 2006). Nearly all of them found "resounding" evidence of statistically significant associations between the built environment and travel behavior, independent of self-selection influences: "Virtually every quantitative study reviewed for this work, after controlling for self-selection through one of the various ways discussed above, found a statistically significant influence of one or more built environment measures on the travel behavior variable of interest (Cao, Mokhtarian, and Handy 2006).

Mokhtarian and colleagues find research designs used in studies to date all wanting in some respect. Still to be determined through future research are the absolute and relative magnitudes of this influence. What all of this tells us is that the built environment and self selection *both* influence travel choices; we just do not yet know enough to calculate their relative impacts.

## 4.2 The Built Environment May Matter in any Case

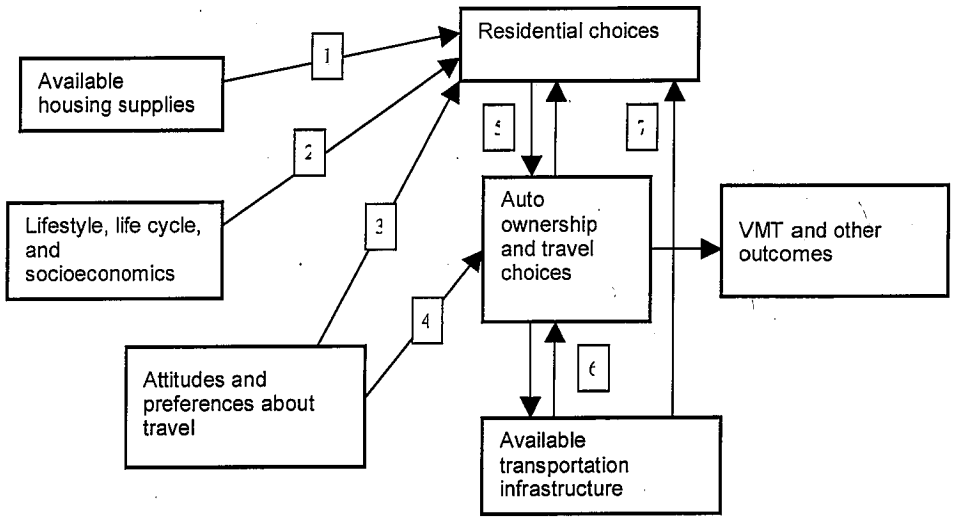
The fact that people to some extent "self select" into neighborhoods matching their attitudes is itself a demonstration of the importance of the built environment in travel behavior. If there were no such influence, people who prefer to travel by transit or nonmotorized modes might as well settle in sprawling areas, where they have no alternative to the automobile.

Whether the association between the built environment and travel is due to environmental determinism or self selection may have little practical import. Where people live ultimately depends on housing supply and demand. As Lund, Willson, and Cervero (forthcoming) note, ". . . if people are simply moving from one transit-accessible location to another (and they use transit regularly at both locations), then there is theoretically no overall increase in ridership levels. If, however, the resident was unable to take advantage of transit service at their prior residence, then moves to a TOD (transit-oriented development) and begins to use the transit service, the TOD is fulfilling a latent demand for transit accessibility and the net effect on ridership is positive)."

The conceptual model in Figure 4-3 indicates why self selection may be less important than the recent focus in the literature suggests. Attitudes about travel have direct effects on travel choices (link 4). Attitudes also may have indirect effects through the mediator, residential choice (link 3). This is the theory of self selection. If link 3 is strong relative to link 4, self selection may be the main mechanism through which the built environment affects travel and health outcomes. If link 3 is weak, residential choices may still affect travel directly through link 4. This is the theory of environmental determinism.

Note that strong self selection may actually enhance the effect of the built environment on travel, not render it insignificant, as some of the literature implies. Whether it does or not depends on housing supply (link 1) relative to demand (links 2 and 3). Housing supply may affect travel regionally if certain types of residential environments are undersupplied. We will refer to this as the theory of latent demand. As shown in Figure 4-4, the ability to self select (link 3) is moderated by housing supplies.

**Figure 4-3 Mechanisms by which Attitudes and Preferences Might Affect Travel Choices and VMT**




Think of travel outcomes in two dimensions (as in Figure 4-4). One dimension relates to the relative strength of self selection versus environmental determinism. The other depends on the supply of walkable or transit-served places relative to demand across a region. Of course, these dichotomies are false. Both dimensions are continuous, and reality almost certainly lies somewhere along a continuum.

But for three of the four extreme scenarios, the development of new walkable, transit-oriented places should lead to net increases in walking and transit use across the region. Even if self selection is the dominant mechanism through which the built environment influences travel, developers meeting latent demand for walkable, transit-oriented environments will be contributing to reduced VMT. Indeed, the only way that these developers will not have a positive impact is if such places already are adequately supplied.

This does not appear to be the case. There is ample evidence that the demand for walkable, transit-oriented environments far exceeds the current supply. In a study of residential preferences in Boston and Atlanta, Levine, Inam, and Tong (2005) find a huge unmet demand for pedestrian- and transit-friendly environments, particularly among Atlanta residents (see Figure 4-5). It causes these researchers to conclude:

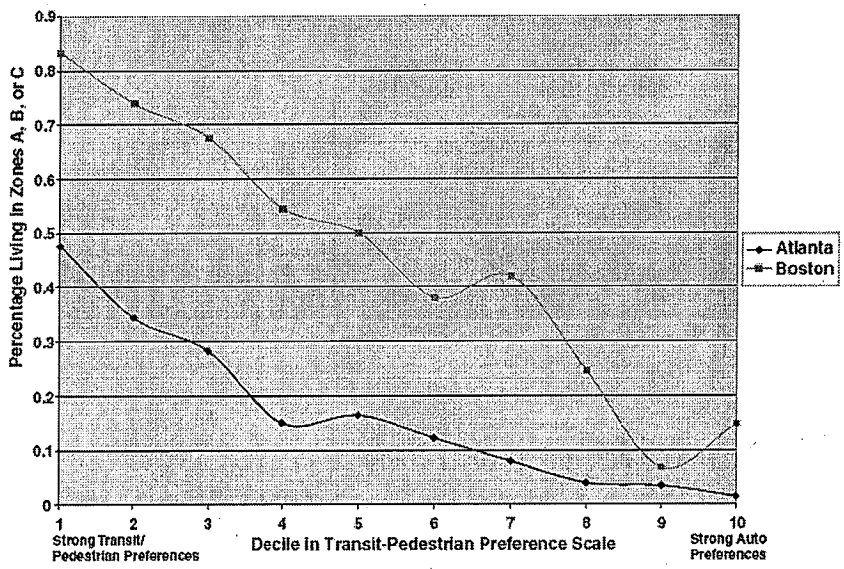
> . . . given the gap depicted in Figure [4.5], it seems unlikely that new transit-oriented housing in Atlanta would fill up with average Atlantans; rather, it would tend to be occupied by people with distinct preferences for such housing who previously lacked the ability to satisfy those preferences in the Atlanta environment. Self-selection in this case would be a real effect, but it would hardly negate the impact of urban form on travel behavior. This is because in the absence of such development, those households would be unlikely to reside in a pedestrian neighborhood and would have little choice but to adopt auto-oriented travel patterns.

For more data on the growing and unmet demand for compact development, see Belden Russonello & Stewart (2003), Myers and Gearin (2001), Center for Transit-Oriented Development (2004), Levine and Frank (2007), Logan (2007), and Nelson (2006).

**Figure 4-4 Effect of New Walkable, Transit-Oriented Developments on Regional VMT**

| | Self Selection Dominates | Environmental Determinism Dominates |
|---|---|---|
| Walkable, transit-oriented places undersupplied at present | VMT decreases | VMT decreases |
| Walkable, transit-oriented place adequately supplied at present | VMT stays the same | VMT decreases |

**Figure 4-5 Relationship of Transit-Pedestrian Preference to Residence in Transit- and Pedestrian-Friendly Zones**
*Source: Levine, Inam, and Tong 2005*




Thus, it is clear that both self selection and environmental determinism may account for VMT reductions with compact development. A recent study in the San Francisco Bay Area suggests that more than 40 percent of the ridership bonus associated with TOD is a product of residential self selection (Cervero and Duncan 2003). Whatever the source, regional transit ridership is higher than it would be otherwise, and regional VMT is lower.

# 5. Induced Traffic and Induced Development

Figure 4.3 illustrates two additional links with potential impacts on regional VMT. Link 6 represents a phenomenon called induced traffic, link 7 a related phenomenon called induced development.

Tony Downs of the Brookings Institution first explained the phenomenon of induced traffic in his 1962 "Law of Peak-Hour Traffic Congestion." As he explained more recently,

> ... traffic flows in any region's overall transportation networks form almost automatically self-adjusting relationships among different routes, times, and modes. For example, a major commuting expressway might be so heavily congested each morning that traffic crawls for at least thirty minutes. If that expressway's capacity were doubled overnight, the next day's traffic would flow rapidly because the same number of drivers would have twice as much road space. But soon word would spread that this particular highway was no longer congested. Drivers who had once used that road before and after the peak hour to avoid congestion would shift back into the peak period. Other drivers who had been using alternative routes would shift onto this more convenient expressway. Even some commuters who had been using the subway or trains would start driving on this road during peak periods. Within a short time, this triple convergence onto the expanded road during peak hours would make the road as congested as it was before its expansion (Downs 2004).

Controversy exists over whether and to what extent the addition of highway capacity induces new traffic and promotes urban development in proximity to the added highway capacity. The notion of induced traffic challenges the view that the expansion of existing roads or the building of new roads will necessarily relieve highway congestion.

The concept of induced development challenges the view that highway investments are a response to growth and development, as opposed to a cause of them. In the highway "wars" that ensue between environmental and development interests, opposing sides have very different positions on the nature and magnitude of induced traffic and induced development. In this brief review, we will attempt to sort out facts from debating points.

## *5.1 Case Study: Widening Interstate 270*

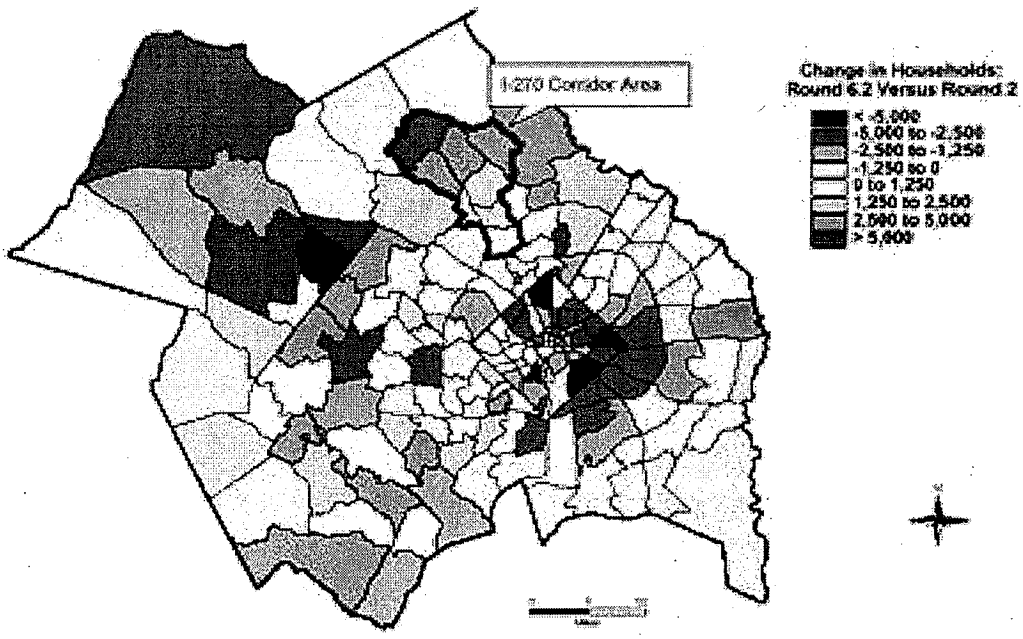
Interstate 270, which angles to the northwest from the Washington, D.C., beltway in Montgomery County, Maryland, was widened in the late 1980s and early 1990s. In 1999, the *Washington Post* ran a story comparing actual traffic volumes on I-270 to pre-construction projections (*Washington Post* 1999). The article declared the widening a failure based on the amount of induced traffic, which effectively used up the added capacity. By the year 2000, traffic volume for certain sections of I-270 already exceeded forecasts for 2010.

This was a time of growing interest in the phenomena of induced traffic and induced development. The Maryland-National Capital Park and Planning Commission and the Metropolitan Washington Council of Governments responded with a study that suggested that highway-induced development was mainly responsible for the high and premature levels of congestion on I-270 (NCRTPB/MWCOG 2001). Also blamed was the failure to build all transportation facilities in the adopted regional transportation plan. Some projects had been delayed and others dropped.

On the subject of induced development, the study concluded that "higher observed traffic volumes relative to the 1984 forecast appear to be due in large part to shifts in population, employment, and travel to the I-270 corridor from other areas in the region, rather than to entirely new travel." For the region as a whole, population growth was 5 percent lower than had been forecasted in 1984, while employment growth was 9 percent higher. The two together suggested small (if any) net impacts of I-270 on regional growth.

However, population and employment had clearly shifted to the I-270 corridor, at the expense of other areas. Specifically, population and employment in the I-270 corridor were, respectively, 23 and 45 percent higher than forecasted in 1984. For all of Montgomery County, they were 7 and 21 percent higher than forecasted. Meanwhile, population and employment were 9 and 23 percent lower than forecasted in Prince George's County, and 29 and 3 percent lower than forecasted in the District of Columbia. These shifts in development are illustrated in Figures 5-1 and 5-2.

**Figure 5-1 Difference between Actual and Forecasted Households by Subarea (2000)**
*Source: NCRTPB/MWCOG 2001.*



**FAX**

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approved 1/16/08
Chief Engrs

# Tanya Veldhuizen

# December 2007

December 2007

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| 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | | | | | | |

January 2008

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| Monday | Tuesday | Wednesday | Thursday | Friday | Sat/Sun |
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| | | | | | 2 |
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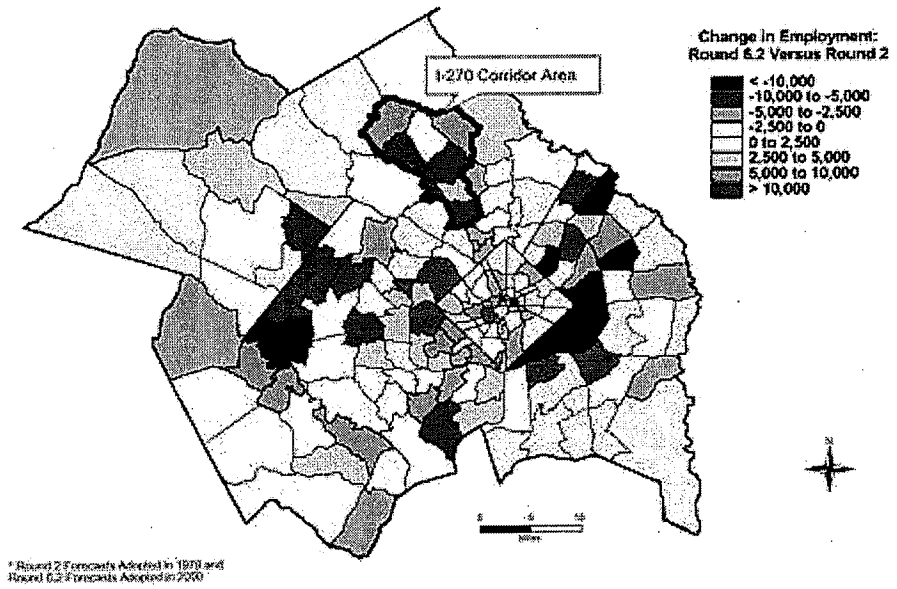
| Sick Leave - 4 hours | Sick Leave - 4 hours | Sick Leave - 4 hours | Sick Leave - 4 hours | Sick Leave - 4 hours | |
| | | | | | 9 |
| 10 | 11 | 12 | 13 | 14 | 15 |
| Sick Leave - 4 hours | Sick Leave - 4 hours | Sick Leave - 4 hours | Sick Leave - 4 hours | Excess Hours - 4 hours | |
| | | | | | 16 |
| 17 | 18 | 19 | 20 | 21 | 22 |
| Excess Hours - 4 hours | Excess Hours - 4 hours | Excess Hours - 4 hours | Excess Hours - 4 hours | Excess Hours - 4 hours | |
| | | | | | 23 |
| 24 | 25 | 26 | 27 | 28 | 29 |
| Excess Hours - 4 hours | Christmas Holiday | Excess Hours - 4 hours | Excess Hours - 4 hours | Excess Hours - 4 hours | |
| | | | | | 30 |
| 31 | | | | | |
| Excess Hours - 4 hours | | | | | |

**Figure 5-2 Difference between Actual and Forecasted Employment by Subarea (2000)**
*Source: NCRTPB/MWCOG 2001.*




The experience with the I-270 widening mirrors the literature on highway-induced traffic and highway-induced development.

## 5.2 The Magnitude of Induced Traffic

Cervero (2002) compares elasticity values across studies in a meta-analysis. Again, an elasticity is the percentage change in one variable that accompanies a 1 percent change in another variable. An elasticity of VMT with respect to lane miles of 0.5 implies that every 1 percent increase in lane miles is accompanied by a 0.5 percent increase in VMT. At the facility level, a 100 percent increase in lane miles is what we would get if a facility were widened from two to four lanes.

In his meta-analysis, Cervero (2002) extracts the average elasticities shown in Figure 5-3.

**Figure 5-3 Elasticities of VMT with Respect to Capacity**
*Source: Cervero 2002.*

| | Facility-Specific Studies | Areawide Studies |
|---|---|---|
| Short-term | 0 | 0.4 |
| Medium-term | 0.265 | NA |
| Long-term | 0.63 | 0.73 |

Based on the meta-analysis, Cervero (2002) concludes that ". . . the preponderance of research suggests that induced-demand effects are significant, with an appreciable share of added capacity being absorbed by increases in traffic, with a few notable exceptions." The average long-term elasticity of 0.73 suggests that for every 1 percent increase in areawide highway capacity, VMT increases by 0.73. The actual increase in a given corridor or metropolitan area depends on the level of congestion. Adding capacity in an area with no congestion has no effect; adding capacity in an area with severe congestion has huge effects. This is apparent from Figure 5-4, which shows the VMT increase per lane-mile of capacity added in California metropolitan areas. The induced traffic effect is greatest in the congested San Francisco, Los Angeles, and San Diego metro areas (see Figure 5-4).

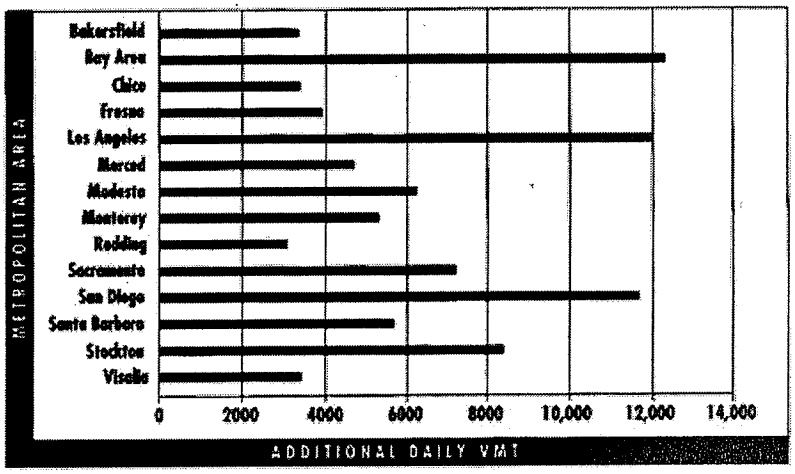



**Figure 5-4 Estimated Additional VMT from an Additional Lane-Mile, California** *Metropolitan Areas Source: Hansen and Huang 1997.*

## *5.3 The Role of Induced Development*

Induced traffic and induced development are related. One can think of induced development as a cause of induced traffic, not immediately but over the longer term. To better understand induced traffic and its connection to induced development, it is necessary to explore the behavioral consequences of additions to roadway infrastructure capacity.

In the short term, a variety of behavioral changes can contribute to increased traffic without any induced development. These include route switches, mode switches, and changes in destination. In addition, new trips may be taken that would not have occurred without the addition in infrastructure capacity.

In the longer run, increases in highway capacity may lower travel times so that residents and businesses are drawn to locate in the area surrounding the expanded highway capacity. The question is always whether the new development that occurs in proximity to the highway was induced to locate there as a consequence of the expansion or whether it would have occurred anyway, regardless of the highway. Indeed, the highway investment may be a response to new or anticipated development, rather than vice versa. If the development itself would not have occurred otherwise, the development and the traffic it generates can be considered induced.

Definitionally, a gray area exists if the development that occurs near a highway would have occurred somewhere else in the region in the absence of the investment. Some would call this induced development, others redistributed development. We use the term induced development liberally, to mean any development that would not have occurred at a given location without a highway investment.

## 5.4 Historical Changes in Induced Development

Clearly, the impacts of highway investments are less today than they once were. Construction of the Interstate Highway System, in particular, has tied virtually every place in the country to everywhere else. Most studies finding sizable highway impacts (for example, Mohring 1961 and Czamanski 1966) date back to the first round of interstate highway construction, which created huge positive externalities for areas gaining access to the network. By the early 1970s, the Interstate Highway System was largely complete. Incremental additions or improvements to the network have since produced comparatively small improvements in interregional accessibility.

How great are highway impacts on economic and land development in the post-interstate era? This is a subject of great debate. In a well-known point-counterpoint, Giuliano (1995) minimized the importance of highway investments for three reasons: "The transportation system in most U.S. metropolitan areas is highly developed, and therefore the relative impact of even major investments will be minor. The built environment has a very long life. . . . Even in rapidly growing metropolitan areas, the vast proportion of buildings that will exist 10 to 20 years from now are already built. . . . Transport costs make up a relatively small proportion of household expenditures."

Cervero and Landis (1995) countered that "although new transportation investments no longer shape urban form by themselves, they still play an important role in channeling growth and determining the spatial extent of metropolitan regions by acting in combination with policies such as supportive zoning and government-assisted land assembly." They then challenged Giuliano's empirical evidence, and presented evidence of their own.

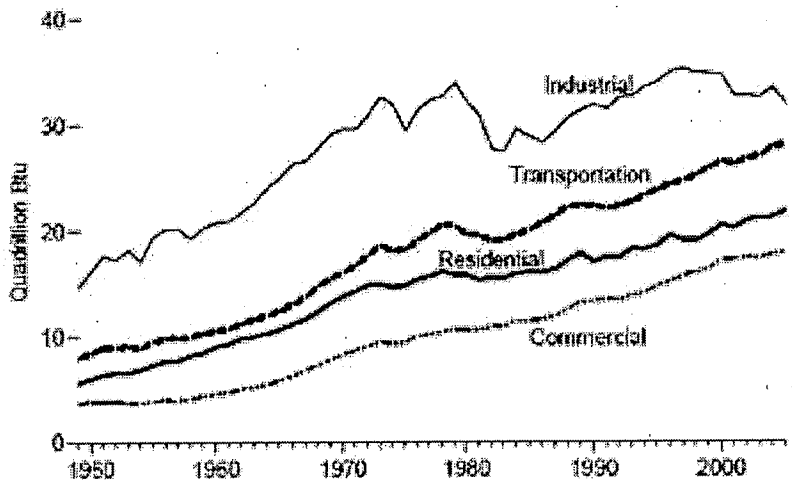
## 5.5 What Is Known about Induced Development

Who is right? Giuliano probably is right about aggregate impacts, while Cervero and Landis probably are right about localized impacts. The induced development literature has been reviewed by Huang (1994), Boarnet (1997), Boarnet and Haughwout (2000), Ryan (1999), and Bhatta and Drennan (2003). A recent review by Ewing (2007) concludes:

- Major highway investments have small net effects on economic growth and development within metropolitan areas. Instead, they mostly move development around the region to take advantage of improved accessibility. Induced development is very close to a zero-sum game.
- Highway investment patterns tend to favor suburbs over central cities, and thereby contribute to decentralization and low-density development.
- Major highway investments may actually hurt regional productivity, if they induce inefficient (read "low-density") development patterns.
- Corridors receiving major highway investments experience land appreciation, and therefore are likely to be developed at higher densities than developable lands outside the corridors.
- Highways may be necessary to induce development, but they are not sufficient to do so. To the extent that current planning and zoning caps hold, impacts within a corridor will be moderated.
- Counties receiving major highway investments attract population and employment growth to a greater degree than they would otherwise.
- Nearby counties may experience more or less growth than they would otherwise, depending on the strength of spillover effects.
- Nonresidential development is more strongly attracted to major highways than is residential development, particularly in the immediate vicinity of facilities.
- The induced development impacts of interstate-quality highways are wider and deeper than those of lesser highways and streets.
- It takes many years after construction for development to adjust to a new land use/transportation equilibrium.
- The induced development impacts of major highways extend out at least one mile, and probably farther.
- The relationship between highway capacity and growth is a two-way relationship, in that growth induces highway expansion as well as the reverse.

# 6. The Residential Sector

**Figure 6-1 Total U.S. Energy Use by End-Use Sector, 1949 to 2005**




With regard to development impacts on energy use and emissions, the transportation sector has gotten most of the attention (Ewing 1994; Kessler and Schroeer 1995; Burchell et al. 1998; Bento et al. 2003; EPA 2003; Frank and Engelke 2005; Frank et al. 2006). This is understandable. The transportation sector is the second-biggest energy user in the United States, and is catching up with the industrial sector (see Figure 6-1). It is the sector that is most reliant on oil as an energy source. However, as a long-term threat to the planet, energy use by the residential sector also is significant. In 2004, the U.S. residential sector produced more than one- fifth of total energy-related $CO_2$ emissions (EIA 2004).

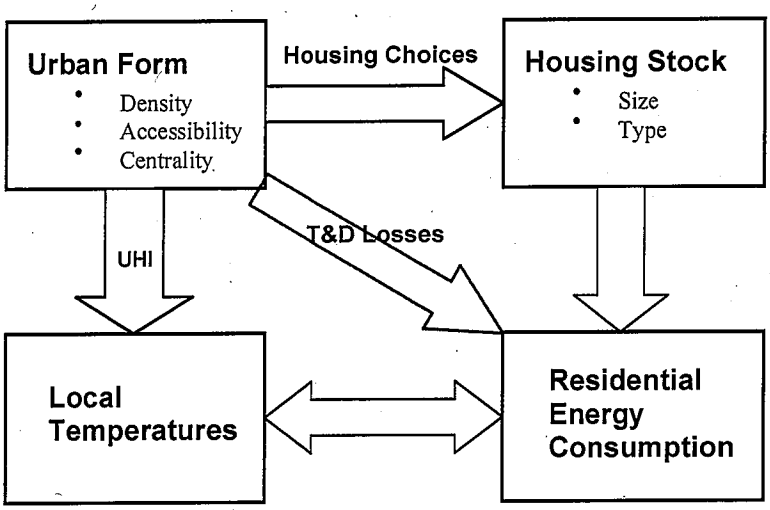
As with the transportation sector, the United States has relied almost exclusively on technological advances to address the problem of limited energy supplies and constantly increasing energy demands of the residential sector (Siderius 2004). Evidence exists that per capita energy use and associated emissions will continue to rise, and that advances in technology alone will be insufficient to achieve sustainable growth in energy use (Kunkle et al. 2004; Lebot et al. 2004; Siderius 2004). Therefore, demand-side measures will be required to keep supply and demand in reasonable balance.

Also like the transportation sector, residential energy use and related emissions have a relationship to urban development patterns. Impacts are felt through changes in housing stock, urban heat islands (UHIs), and transmission and distribution losses (see Figure 6-2). The first two effects have been quantified (see Rong and Ewing 2007). After controlling for household characteristics, residential energy use varies with house type and size, which in turn vary with the degree of urban sprawl. These relationships, taken together, allow us to estimate the effects of urban sprawl on residential energy use, indirectly, through the mediators of house type and size. The average household living in a compact county, one standard deviation above the mean sprawl index, would be expected to consume 17,900 fewer BTUs of primary energy annually[27] than the same household living in a sprawling county, one standard deviation below the mean index.

---

[27] Primary energy is energy contained in raw fuels, which is transformed in energy conversion processes to more convenient forms of energy, such as electrical energy and cleaner fuels. In energy statistics, these more convenient forms are called secondary energy.

**Figure 6-2 Causal Paths between Urban Development Patterns and Residential Energy Consumption**
*Source: Rong and Ewing 2007.*




UHI effects are strongest in compact areas, leading to an increase in cooling degree-days and a reduction in heating degree-days. Degree-days, in turn, directly affect space heating and cooling energy use. These relationships, taken together, allow us to estimate the effects of urban sprawl on residential energy use indirectly, through the mediating effect of UHIs. Nationwide, as a result of UHIs, an average household in a compact county, one standard deviation above the mean sprawl index, would be expected to consume 1,400 fewer BTUs of primary energy annually than an average household in a sprawling county, one standard deviation below the mean index.

Throughout most of the nation, the two effects, housing and UHI, are in the same direction, though.the housing effect is much stronger than the UHI effect. The total average savings of 19,300 BTUs amounts to 20 percent of the average primary energy use per household in the United States

[NOTE: THE FOLLOWING CHAPTER IS STILL IN PRELIMINARY FORM AND IS SUBJECT TO CHANGE]

# 7. Policy and Program Recommendations

Climate stabilization will require the U.S. to reduce GHG emissions by 60 to 80 percent below 1990 levels by 2050. To stay on that path, our GHG emissions will need to be well below 1990 levels by 2030, and leading analysts believe we have less than 10 and possibly less than 5 years to get on track.[28] In the transportation sector, progress will be required on all three legs of the stool: vehicle efficiency, fuel content, and vehicle miles traveled (VMT).[29] The national policy discussion on vehicles and fuels is mature and active, and a variety of proposals would have the automobile and oil industries take responsibility for their contributions to GHG. But no one has been put in charge of reducing the GHG impacts of VMT growth.

In this chapter, we aim to identify the roles and responsibilities for various levels of government to meet our climate challenge. Civic leaders, consumers, businesses, and other stakeholders can also make substantial contributions.

The key to substantial GHG reductions is to get all policies, funding, incentives, practices, rules, codes, and regulations pointing in the same direction to create the right conditions for smart growth. Innovative policies are often in direct conflict with the conventional paradigm that produces sprawl and automobile-dependence. One example is the link between federal transportation funding and VMT levels, thereby rewarding states for VMT growth.[30] Another example is the low-density zoning that keeps localities car-dependent, undermining local expenditures on transit, walking, and cycling.

Fortunately, many communities and states have demonstrated that comprehensive reforms can both reduce the need for driving, and improve overall quality-of-life. They have responded to public demands and market forces pushing for compact development, and $CO_2$ emissions reductions have been a bonus.

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[28] Rosina Bierbaum, Dean of the School of Natural Resources at U. of Michigan, presentation to Presidential Climate Action Program analyzing trends in IPCC analyses, June 2006 at Wingspread Conference Center, Racine, WI

[29] Vehicle-hours of travel (VHT) is another useful indicator.

[30] Specifically, the formulas by which the total payout of dollars from the Federal Highway Trust Fund is sub-allocated or "apportioned" to each State rewards such factors as VMT fuel use and lane-miles of travel. An overview of the apportionment process is provided by the GAO 2006 report available at http://www.gao.gov/new.items/d06572t.pdf

## 7.1. Federal Policy Recommendations

Although land use planning and growth management are primarily local and state responsibilities, the federal government plays a powerful role in shaping growth patterns and travel choices through regulations, funding, tax credits, performance measures, technical assistance, and other policies. To accomplish the emissions reductions we have discussed in this book, we recommend the implementation of the following major federal policies. We have chosen these options because they are likely to deliver better performance results (e.g., greater return on investment for every public dollar invested) than the *status quo* while also fostering development with a smaller carbon footprint.

### 7.1.1. Require Transportation Conformity for Greenhouse Gases

Federal climate change legislation should require regional transportation plans to pass a conformity[31] test for carbon dioxide emissions, similar to other criteria pollutants. The Supreme Court ruling in *Massachusetts v. EPA* established the formal authority to consider greenhouse gases under the Clean Air Act, and a transportation planning conformity requirement would be an obvious way for EPA to exercise this authority to produce tangible results.

[31] Transportation conformity for conventional air pollutants (requiring regular assessments and course corrections to prevent transportation programs from undermining timely achievement of clean air standards) was created by the 1977 Clean Air Act Amendments and strengthened when that Act was amended in 1990. In 1991's Intermodal Surface Transportation Efficiency Act (ISTEA), Congress further codified conformity and created the Congestion Mitigation and Air Quality Improvement Program (CMAQ) as a complementary program to help regions achieve conformity (a "carrot" to conformity's "stick").

**What is Conformity?**[1]

Under Section 110 of the Clean Air Act,[1] states develop and implement air pollution control plans called State Implementation Plans (SIPs) to demonstrate attainment with National Ambient Air Quality Standards (NAAQS) set by EPA at levels deemed necessary to protect public health and welfare. The 1990 Clean Act Amendments, along with subsequent transportation legislation, required air quality and transportation officials to work together through a process known as conformity. A metropolitan region that has exceeded the emission standards for one or more of the pollutants must show that the region's transportation plan will conform to applicable SIPs and contribute to timely attainment of the NAAQS. According to the regulations, a proposed project or program must not produce new air quality violations, worsen existing violations, or delay timely attainment of the NAAQS.[1] The metropolitan planning organizations (MPOs) must demonstrate this conformity through their long range transportation plans and transportation improvement programs (TIPs) – which identify major highway and transit projects the area will undertake over a 20-25 year period. Projects that do not conform cannot be approved, funded or advanced through the planning process, nor can they be implemented unless the emissions budget in the SIP is revised.

If a region's TIP has expired without adopting a new TIP projected to stay within the motor vehicle emissions budget in the SIP, the area faces what is known as a conformity lapse. During this period, the MPO cannot approve funding for new transportation projects or new phases of previously funded transportation projects except for those projects that are adopted as Transportation Control Measures in the SIP or are otherwise exempt from conformity as air quality neutral activities. If an area fails to submit a required SIP by a deadline, it may face a "conformity freeze", in which it cannot approve any new projects until this deficiency is remedied, and if this failure is prolonged, can face the ultimate sanction of losing federal transportation funding. For some metropolitan areas, this potential loss of transportation funds can be more than $100 million per year.[1] While there have been 63 areas in the US that have suffered a conformity lapse, no state or region has ever lost federal transportation funds as a result of a conformity lapse, freeze, or sanctions.

State and local governments would be required to adopt mobile source $CO_2$ emission reduction budgets (like the emissions budgets for other pollutants) that demonstrate reasonable progress in limiting emissions.[32] Currently, regions that fail to develop transportation plans consistent with "Reasonable Further Progress" goals risk curbs on federal transportation funds. This could be reinforced by incentives that reward places that effectively reduce per capita VMT. Conversely, a portion of transportation funds could be withheld from places that fail to make progress toward reducing VMT *per capita* (see discussion below in State Policy section).

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[32] The California Energy Commission offered a similar proposal to require regional transportation planning and air quality agencies to adopt regional growth plans that reduce GHG emissions to state-determined climate change targets. California Energy Commission, "The Role of Land Use in Meeting California's Energy and Climate Change Goals." http://www.energy.ca.gov/2007_energypolicy/documents/

Though we acknowledge that to date, land use and transportation demand management (TDM) policies have generally not played a large role in meeting regional conformity requirements,[33] we believe that comprehensive strategies would be more successful. Responsibility should be "nested" so that the federal government is responsible for the GHG impacts of federal transportation spending (see Green-TEA discussion below) and state and local governments bear responsibility for the GHG impacts of their transportation spending.

### 7.1.2 Use Cap-and-Trade (or Carbon Tax) Revenues to Promote Infill Development

Many climate proposals[34] focus on the creation of a market-based cap-and-trade system similar to policies adopted in Europe[35] and ones that are likely to be formed in California[36] and other states. By placing a price on greenhouse gas emissions, a cap-and-trade system can send the right signal for reducing the emissions associated with vehicle travel.[37] Moreover, regulated parties (such as oil companies) will have incentives to support policies that slow VMT growth, because actions that increase VMT will make carbon emission allowances more costly. Therefore, federal policies that subsidize growth patterns that increase *per capita* VMT would generate higher overall compliance costs.

A related issue that is being discussed within the federal cap-and-trade debate is how to best use the revenues generated by such a system. If cap-and-trade is adopted, the value of carbon allowances will be worth an estimated $50 to $300 billion per year by 2020 based on recent Congressional proposals. A portion of these revenues could be used to fund infrastructure for infill development, technical assistance to help communities seeking to rewrite codes and regulations that inhibit infill development, and transportation choices that support compact infill development.

In order to ensure adequate emission reductions, to accelerate the introduction of new technology into the marketplace and to moderate the price of allowances, some are proposing policies which complement a cap-and-trade system. Specifically, two of three legs of the transportation sector stool would be covered by new product performance standards. In the case of the auto industry, the longstanding tool is the Corporate Average Fuel Economy (CAFE) program. California is developing a low-carbon fuel standard (LCFS) that leads the nation. With the successful launch of the new Leadership in Energy and Environmental Design—Neighborhood Development

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[33] For example, in its 2002 SIP, the State of Maryland included smart growth policies that it expects to yield modest air quality benefits. Sacramento anticipates significant emissions savings from land use measures in its Blueprint transportation plan. In Atlanta, a modeling exercise on the emissions benefits of infill development rescued the region from its conformity lapse and associated restrictions on funding new transportation projects (1998-2000), but the region lacked the political support or transit funding to implement the modeled smart growth scenario. See CCAP (2004), "Two for the Price of One: Clean Air and Smart Growth (Workshop Primer)." http://www.ccap.org/transportation/smart_two.htm and "Atlanta's Experience with Smart Growth and Air Quality." http://www.ccap.org/transportation/smart_two.htm

[34] For example, see, Pew (2007), "Senate Greenhouse Gas Cap-And-Trade Proposals," http://www.pewclimate.org/docUploads/Economy-wide%20bills%20110th%20Senate%20-%20August%202.pdf

[35] See European Union Greenhouse Gas Emission Trading Scheme, http://ec.europa.eu/environment/climat/emission.htm

[36] For example, see California Market Advisory Committee, http://www.climatechange.ca.gov/policies/market_advisory.html

[37] For example, see Winkelman et. al (2000), "Transportation and Domestic Greenhouse Gas Emissions Trading," http://www.ccap.org/pdf/TGHG.pdf

(LEED-ND) certification standards from the U.S. Green Building Council, now may be the time to consider something analogous for new development products. This is especially so if public funding—allowance revenue, gas tax revenue—is to be made available to support such "cooler growth." Public support should be coupled with some sort of guarantee of performance, whether in the form of standards or similar policy for new development.

Other options, such as a carbon tax, are also being debated and could also provide reinforcing price signals for VMT reduction and revenue for compact development and more transportation choices.

### 7.1.3 Enact "Green-TEA" Transportation Legislation that Reduces GHGs

The Intermodal Surface Transportation Efficiency Act of 1991 (known as ISTEA), represented a revolutionary break from past highway bills with its greater emphasis on alternatives to the automobile, community involvement, environmental goals, and coordinated planning. The next surface transportation bill could bring yet another paradigm shift—it could further address environmental performance, climate protection and green development. We refer to this opportunity as "Green-TEA."[38]

Transportation policy is climate policy. With another $300 billion to be reauthorized by Congress in 2009, it represents the largest category of federal infrastructure funding. As discussed in this book, how this money gets spent has a major impact on the nation's VMT and greenhouse gas emissions.

***Accountability for GHG Impacts of Transportation Spending.*** Congress should require the U.S. Department of Transportation (US DOT) to assess the GHG impact of proposed reauthorization bills to determine conformity with national climate goals (i.e., a target percentage below 1990 levels by 2030, consistent with reaching 60-80 percent below 1990 GHG levels by 2050). This analysis would be based in large part on newly required regional scenario analyses conducted by Metropolitan Planning Organizations (MPO). If the transportation bill is expected to generate emissions that are inconsistent with national climate goals, then US DOT should develop a national climate plan that conforms to a mobile source GHG emissions budget and work with MPOs to modify their plans accordingly.

***More Funding for Transportation Choices.*** A half-century ago, the U. S. adopted the Federal-Aid Highway Act of 1956, launching an unprecedented engineering project that quickly changed everything about the way Americans travel and build communities. Today, the Interstates are complete, and we need to invest in an equally ambitious effort to complete the rest of the nation's transportation system. While we work to maintain our world-class highway network, we must build other world-class systems, including public transportation and bicycling and pedestrian networks. These should be complemented by policies that encourage compact, mixed-use development, telecommuting, and pricing of auto use to better manage congestion and raise revenue for alternatives, such as New York City's proposed congestion pricing system.[39]

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[38] As proposed by the Center for Clean Air Policy, see http://www.ccap.org/transportation/smart.htm.
[39] http://www.nyc.gov/html/planyc2030/downloads/pdf/full_report.pdf.

Such investment is badly needed. Demand for New Starts funding is so great that most cities offer far more than the required local match to secure federal funds. Roughly 300 transit projects are authorized in the current federal transportation bill, yet funding is far below demand, producing only about a dozen projects every six years. The process to secure federal funding is also notoriously burdensome and time-consuming. Bicycle and pedestrian travel has also increased in the last decade, and is anticipated to rise. Currently, dedicated federal funding for these "non-motorized" choices stands at about 1.4 percent, even though bike and walking trips account for between 8 and 9 percent of all trips taken.

***More Funding for Repair and Reconstruction.*** Making repair and reconstruction of existing infrastructure the top priority is consistent with climate change goals. Less money should be allocated to new or expanded highways, until deficiencies in critical facilities (e.g., those that threaten public health and safety) are eliminated and even then, only if highway projects can be shown to reduce greenhouse gas emissions and VMT.

"Fix-it-first" policies would establish powerful incentives for reinvestment in existing neighborhoods.[40] New infrastructure investment would stimulate infill development and opportunities for more transportation choices, shorter trips, and reduced GHG emissions. Investment in repairs will help ensure that our bridges, tunnels, and other facilities are safe to use. Such investments can be justified on cost-effectiveness grounds. For example, a recent report from the Sacramento Area Council of Governments found that providing infrastructure for sprawl developments costs an average of $20,000 more per unit than for smart growth developments. With regard to repair, deferred maintenance may reduce expenditures in the short term, but years of neglect create poorly performing infrastructure with much larger long-term repair and reconstruction costs. Deteriorating infrastructure in a community can also discourage private investment.

Increased investment would make up for the federal government's flagging contribution to infrastructure maintenance over the past several decades. The graphs below show that although both capital and operations & maintenance (O & M) spending have grown dramatically since 1980, the federal share of O & M has not risen at the same rate. This has increased pressure on state and local governments to make up the gap in funding needed to maintain aging infrastructure. The problem is particularly evident in older suburban neighborhoods where developers are seeking to build compact mixed-use projects but are facing resistance from residents concerned about their capacity to accommodate growth.

A fix-it-first policy can be implemented through several mechanisms. One option is to apply strict performance-based criteria to core funding programs (National Highway System, Interstate Maintenance, Surface Transportation Program, and Bridge Program) so that no funds can be spent on new roadway capacity until all critical facilities are brought up to minimum safety standards. Another alternative is to create minimum set-aside requirements for repair and reconstruction. For existing programs, like the Bridge and Interstate Maintenance programs, funding could be also increased to ensure that such set-aside requirements are practical.

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[40] The declaration of findings in the 1991 ISTEA legislation includes an emphasis on maintaining and enhancing system components before investing in new ones; similar State legislation enacted in New Jersey could provide a model to follow in other States.

To ensure that locales follow through with plans for redevelopment, a share of federal funds could be held back and rewarded only after infill-enabling policies are implemented successfully. Such a strategy has been used for infrastructure investment under Massachusetts' smart growth program.

The private sector can also be enlisted in the effort. Specifically, tax credits and low-interest revolving fund loans should be offered to privately financed projects that revitalize and retrofit public infrastructure. Such investments would not only benefit those projects, but would also catalyze investment in adjacent areas.

### 7.1.4 Replace Funding Formulas with Funding Based on Progress Toward National Goals

We recommend that transportation agencies develop a system of performance measures to meet specific national, state, and local goals pertaining to climate stabilization, energy security, accessibility for low-income and disabled persons, and safety. We believe that a mode-neutral plan to achieve such goals will result in several-fold increases in funding for public transportation, bicycling and pedestrian facilities, and reinforcing land-use changes. The kinds of programs that might see major increases include federal New Starts and Small Starts, federal Safe Routes to School, Transportation Enhancements, the Non-Motorized Pilot Program (which should be converted from a pilot to a regular program), and the Jobs Access and Reverse Commute Program.

Applying performance criteria to roadway infrastructure will likely result in a decrease of unnecessary and traffic inducing highway projects, because most projects have never been scored against any rigorous performance criteria. Many are among the 6,371 new earmarks from the 2005 SAFETEA-LU Act or are otherwise justified based on criteria that are much looser than those faced by transit proposals. Also, they are less likely to be able to compete as well with regard to the urgent national priorities of energy security and climate change discussed in this book.

To achieve a performance-oriented approach, our nation will have to fundamentally transform its transportation policies. Current funding formulas are based on VMT, fuel use and lane miles – thus rewarding increased GHG emissions. Moreover, gasoline tax revenues are dependent on the steady or increasing VMT levels and more funding is allocated to areas with more VMT. As long as our transportation industry is dependent on VMT levels being high, the task of reducing VMT will be extremely difficult. The current crisis in the federal transportation trust fund is actually an excellent opportunity to rethink how revenues are raised in light of national priorities for energy and climate.

States could require metropolitan transportation improvement programs (TIPs) to demonstrate their compliance with statewide measures, creating pots of money to use as rewards for meeting desired targets, and tracking the effectiveness of various VMT-reduction strategies. Potential measures to be achieved by 2030 might include:

- Reduce per capita VMT in a metropolitan region by 25 percent;
- Reduce statewide per capita VMT by 20 percent;
- Reach a state of good repair for roads and bridges to address safety and maintenance issues; and
- Double access to transportation alternatives and increased mode shares for transit, bicycling, walking, carpooling, or telecommuting to expand the transportation choices available to all Americans.

The original ISTEA legislation, as passed by the Senate in 1991 (and way ahead of its time), provides a model of how federal funding could be transformed to a performance-based system. This legislation would have created an Energy Conservation, Congestion Mitigation, and Clean Air Act Bonus program. The original language was as follows:

> This paragraph shall apply beginning in fiscal year 1993 and shall apply only to those States with one or more metropolitan statistical areas with a population of two hundred fifty thousand or more. The amount of each such State's Surface Transportation Program funds determined pursuant to section 133(b)(1)(A)(i) shall be reduced by multiplying such amount by a factor of 0.9 if the State's vehicle miles of travel per capita is more than 110 per centum of its vehicle miles of travel in the base year. Reductions in apportionments made pursuant to the preceding sentence shall be placed in a Surface Transportation Bonus Fund and shall be used, to the extent such funds are available, to increase the amount of Surface Transportation Program funds determined pursuant to section 133(b)(1)(A)(i) by a factor of 1.1 for each State affected by this paragraph, if such State's vehicle miles of travel per capita is less than 90 per centum of its vehicle miles of travel per capita in the base year. Funds remaining thereafter in the Surface Transportation Bonus Fund, if any, shall be apportioned to the States affected by this paragraph in proportion to each State's share of Surface Transportation Program funds determined pursuant to section 133(b)(1)(A)(i) among all such States prior to any adjustments made pursuant to this paragraph. Funds so apportioned shall be treated as funds pursuant to section 133(b)(1)(A)(i) area treated. For the purposes of this paragraph, the term "base year" shall mean the year 1990 for fiscal years 1993, 1994, and 1995, and shall mean the year 1995 for fiscal years 1996 and all subsequent fiscal years."

Such a bonus program could be administered either through state allocations and metropolitan suballocations, or better still, through direct allocations to MPOs (as described in the next section).

### 7.1.5 Provide Funding Directly to Metropolitan Planning Organizations

When MPOs were first established and formally recognized, a number of federal programs requiring regional planning came within their purview (Lewis and Sprague 1997). With the "new federalism" of the Reagan administration, MPOs lost most of the programs they briefly controlled (McDowell 1984). The one program remaining was transportation planning, but new regulations gave states full sway in determining the functions for MPOs. This meant that many MPOs were in the role of merely "rubber-stamping" decisions already made by state highway departments (Solof 1997).

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 reversed this trend, somewhat. ISTEA gave MPOs new authority and responsibilities. MPOs were to craft 20-year long-range transportation plans that were fiscally constrained to meet realistic revenue projections. They also had to adopt short-range transportation improvement programs to formally allocate federal transportation dollars to specific projects. They also now had some additional money to allocate. Before ISTEA, federal law mandated that states siphon off a tiny percentage (less than 1%) of their allocation of federal transportation dollars for MPOs. This money did not fund projects; it was to be used for MPO basic operations (staff, facilities, etc.). The funds for projects had to come through the state DOT, and hence was subject to the state's discretion and priorities.

ISTEA changed this by providing a minimum suballocation to MPOs (with 200,000+ population): in addition to providing some operating funds, states had to guarantee a minimal amount of project funding to their MPOs. Under the current transportation law, SAFETEA-LU, that amount is 5% of a state's federal highway allocation (Wolf, Puentes, Sanchez and Bryan 2007).

As important as these changes were, they have hardly made a dent in what is an increasingly inequitable distribution of transportation dollars. Metropolitan areas contain more than 80% of the nation's population and 85% of our economic output (Puentes and Bailey 2005). Investment by state DOTs in metropolitan areas lags far behind these percentages (Hill, Geyer, Puentes, et al 2005).

The issue is not just the *amount* of funding; it is also the authority to decide *how* the money is spent. More than one-third of the states that receive Congestion Management Air Quality funds—funds that by definition are to be used in MPO areas—do not suballocate those funds to their respective MPOs. Only 12 states suballocate federal Transportation Enhancement program dollars to MPOs. The state decides how these funds are to be spent. Even with the 5% of funds that are required to be suballocated to MPOs, many MPO staff report that the state DOT still wields substantial influence (Puentes and Bailey 2005).

What is necessary to remedy the long history of structural and institutional causes behind these inequities is a new system of allocating federal transportation funds directly to metropolitan areas. Instead of sending federal allocations to the states and expecting the states to "do the right thing" for metropolitan areas, future federal legislation should provide for the direct allocation funds to MPOs, without filtering funds through state DOTs.

Moreover, the amount of allocation should be closer to the proportion of an MPO's population and economic activity compared to other MPOs and non-MPO areas in the same state. A starting basis for making these calculations is the point-of-sale gas tax collection. Because different states have different relative demands for rural and interstate facilities, this formula could be adjusted on a state-by-state basis to reflect those variations.

### 7.1.6 Develop a National Blueprint Planning Process that Encourages Transportation Choices and Better System Management

Good planning is critical to the viability of alternative transportation modes and land use reforms at a regional scale. The State and Metropolitan Planning sections of the transportation reauthorization bill (Green-TEA) could require Land Use and Transportation Scenario Analyses for all regional transportation plans. Near-term Transportation Improvement Programs and Long Range Transportation Plans currently require alternatives analyses for specific large projects, but not for the full program or land use plans. It is difficult to discern the benefits from coordinated transportation land use policies on a project-by-project basis. Therefore, under the current system, innovative land use-based policies are more difficult to justify.

The next federal transportation bill should fix this problem by examining both the project scale and cumulative benefits of projects. It should also increase funding for coordinating regional transportation and land use planning to facilitate maximizing opportunities for transit-oriented development, intermodal transportation centers, and more compact, walkable neighborhoods. Scenario and visioning initiatives should also include robust public participation components. Efforts such as the California Blueprint Planning Grants and Blueprint Learning Network provide useful models for other states and regions.[41] Regions whose plans help attain performance goals should be able to access additional funding for implementation and other uses. A "Green-TEA" could establish a National Blueprint Learning Network and National Blueprint Planning Grants.

### 7.1.7 Place More Housing Within Reach

Many homebuyers "drive til they qualify," that is, they purchase a less expensive home further away from where they would ideally like to live.[42] With rising gasoline costs, the financial trade-off between a longer commute and cheaper housing is changing.[43] The potential savings from living in a convenient location with transportation choices is becoming a more important aspect of affordability.[44]

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[41] California Department of Transportation (2007), "Blueprint Learning Network." http://www.dot.ca.gov/hq/tpp/offices/orip/BLN.htm. Also see California Department of Transportation (2007), "California Regional Blueprint Planning Program." http://calblueprint.dot.ca.gov/

[42] Carrie Makarewicz, Tom Sanchez et. al. , Housing and Transportation Financial Tradeoffs and Burdens for Working Households in 28 Metropolitan Regions, Center for Neighborhood Technology and Virginia Tech, 2006, at H-T-Tradeoffs-for-Working-Families-n-28-Metros-FULL.pdf.

[43] Barbara Lipman (ed), A Heavy Load: The Combined Housing and Transportation Burdens of Working Families, Center for Housing Policy, National Housing Conference 2006 at www.nhc.org.

[44] Scott Bernstein, Carrie Makarewicz, Kevin McCarty; ***Driven to Spend***, Center for Neighborhood Technology and Surface Transportation Policy Partnership, 2005, at www.transact.org. Center for Neighborhood Technology and Center for Transit Oriented Development, The Affordability Index: A New Tool for Measuring the True

The Congressionally chartered Millennial Housing Commission has called for a dramatic increase in investment for housing that is affordable to a wide range of individuals and working families of modest means, including teachers, firefighters, nurses, and older Americans. Contrary to widespread beliefs, transit oriented development serves an extremely diverse population and will continue to do so.[45] Greatly expanding the supply of housing in walkable neighborhoods with high-quality transit is a way to satisfy this unmet demand and offer living arrangements that more people can afford. Recent studies for the Federal Transit Administration, the Dept. of Housing and Urban Development, and the Ford Foundation show that much of the need for housing over the next 30 years can be met within walking distance of the nation's 4,000 existing and development transit stations, with significant reduction of VMT.[46] Transportation investments, land development practices, and coordinated planning can also help achieve affordability and access goals while also reducing greenhouse gas emissions. Tax credits can provide a powerful incentive for investment in projects with coordinated land use and affordable housing.

***Smart Location Tax Credit.*** The federal government and some state governments currently provide tax credits for hybrid vehicles, solar technology installation, and other technologies that reduce energy use. The same can be done for smart locations that inherently save energy from vehicle trips. The federal government should direct states to identify smart locations based on the "4D" performance criteria discussed in this book: density, diversity, design, and destination accessibility. Developers of new for-sale or rental units within the most efficient location tiers could qualify for a federal Smart Location Tax Credit. A portion of the incentive can be used to finance affordable units. The transportation choices available in these locations would reduce household transportation costs, an important cost saving to the people living in these homes.

***Housing Rehabilitation Tax Credit:*** For existing housing, federal tax credits for rehabilitation should be provided to revitalize all existing housing units in neighborhoods that generate lower VMT per household than the regional average. As discussed above, federal guidelines would require each state to identify smart location zones that would benefit from the rehabilitation tax credit.

These tax credits serve multiple and critical national needs, from affordable housing to neighborhood reinvestment. They could be funded by reducing subsidies that are incompatible with a national focus on climate change, such as capping the tax-free parking benefit at its current level ($215 per month) or a reduced level (that is, capping it at $200 per month). Also, they could complement existing federal tax incentives that support affordable housing, reinvestment, and historic preservation. The value of tax credits could be increased when the Low Income Housing Tax Credit is also used to benefit smartly located and/or rehabilitation projects, which would help create housing choices for households of different income levels.

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Affordability of a Housing Choice, Brookings Institution, 2006 at www.brookings.edu/metro/umi/pubs/20060127_affindex.htm.

[45] Preserving and Promoting Diverse Transit-Oriented Neighhborhoods, Center for Neighborhood Technology and Center for Transit Oriented Development, 2006 at http://www.cnt.org/repository/diverseTOD_FullReport.pdf.

[46] Hidden in Plain Sight: Meeting the Coming Demand for Housing Near Transit, Center for Transit Oriented Development 2005 at www.reconnectingamerica.org.

The federal Historic Preservation Tax Credit has been one of the most effective tools for revitalizing neighborhoods and repopulating older cities, suburbs, and towns. It should be strengthened and expanded to benefit a wider range of historic properties and to be combinable with other tax credits to facilitate more revitalization and affordable housing production.[47]

### 7.1.8 Create a New Program to Provide Funding to "Rewrite the Rules"

Builders, developers, and industry analysts have conducted market research studies that show a strong and growing demand for walkable, mixed-use neighborhoods with good transit access (see Chapter 1). However, outdated local development regulations (such as subdivision regulations, zoning, parking standards) often make this type of development the hardest thing for a developer to build. Ironically, creating neighborhoods that resemble some of our nation's most appealing places, such as the Georgetown neighborhood in Washington, D.C., or Charleston, South Carolina, is technically illegal in many places because such construction would violate current codes.

The problem is not lack of desire from cities, counties, or towns. In fact, many localities want to modernize their obsolete codes. However, limited planning funds make it hard to both run the development process and redesign it. The federal government provides vast technical assistance resources for everything from agricultural practices to homeland security. Congress should establish a new program to help communities update development rules to support more walkable, town-style, environmentally friendly development.

At the very least, such changes should allow smart growth and compact development a chance to compete by facing the same development process that conventional development must follow. Leveling the playing field would benefit consumers as they shop around for housing and development choices. Most communities already have a surplus of large-lot, single-family homes, and those that wish to change increasingly want to rewrite the rules to encourage compact development, much in the same way that conventional suburban development was subsidized and facilitated through federally discounted mortgages, infrastructure, planning and zoning rules, and other incentives. Changing the rules in just the 50 largest American metropolitan areas would quickly bring more housing, neighborhood, and transportation choices to about 168 million people, or more than half of all Americans.

## *7.2. State Policy Recommendations*

In the absence of major federal action, many states are already moving ahead with plans to reduce $CO_2$ emissions. Some states have banded together in compacts like the Regional Greenhouse Gas Initiative and the Western Regional Climate Change Initiative to create cap-and-trade programs. In addition, twenty-nine individual states have created climate action plans; California and New York have some of the best defined plans.

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[47] Working with the Internal Revenue Service and State Historic Preservation Offices, the National Park Service in 2006 approved 1,253 rehabilitation projects that attracted a record-breaking $4.08 billion in private investment, which is equivalent to a more than 5 to 1 return on federal tax credits invested.

State climate plans in New York, Connecticut and Massachusetts include comprehensive VMT-reduction recommendations, though implementation has been mixed.[48] New York state requires its Metropolitan Planning Organizations to report GHG impacts of Transportation Improvement Programs and Long Range Transportation Plans (both are required to receive federal transportation funds).[49] Connecticut created an Office of Responsible Growth to promote transit-oriented development, provide transit alternatives, encourage walkable communities and target state funding to support development in designated Responsible Growth areas.[50] The California Energy Commission runs a working group tasked with developing recommendations on achieving GHG reductions from smart growth policies. In August 2007, the Commission released a set of policy recommendations on land use and climate change based on a comprehensive review of state and local efforts.[51]

Our recommendations for state policies incorporate development and land use as VMT and $CO_2$ reduction strategies and will work with or without the federal policies described above. They include:

1) Set state targets for VMT as part of a $CO_2$ reduction plan;
2) Adopt state transportation and land use policies that supports climate goals;
3) Improve transportation planning models to reflect the latest research on how the built environment affects travel behavior (regional travel forecasting, trip generation, etc.);
4) Align state spending with climate and smart growth goals;
5) Eliminate perverse local growth incentives; and
6) Create economic development incentives.

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[48] CCAP (2003) on Collaboration with the New York Greenhouse Gas Task Force, "Recommendations to Governor Pataki for Reducing New York State Greenhouse Gas Emissions." http://www.ccap.org/pdf/04-2003_NYGHG_Recommendations.pdf. See also CCAP(2004), "Connecticut Climate Change Stakeholder Dialogue: Recommendations to the Governor's Steering Committee." http://www.ccap.org/Connecticut.htm.

[49] ICF Consulting (2005), "Estimating Transportation-Related Greenhouse Gas Emissions and Energy Use in New York State." http://climate.dot.gov/docs/nys.pdf.

[50] Rell (2006), Executive Order 15. http://www.ct.gov/governorrell/cwp/view.asp?A=1719&Q=320908.

[51] California Energy Commission, "The Role of Land Use in Meeting California's Energy and Climate Change Goals," August 2007. http://www.energy.ca.gov/2007publications/CEC-600-2007-008/CEC-600-2007-008-SF.PDF.

### 7.2.1. Set State Targets for Vehicle-Miles of Travel

***Establish a GHG Reduction Plan That Includes a Target for VMT Reductions***

If the federal government does not act to reduce GHG emissions and VMT, states can take the lead and establish their own goals. Whether federally or state driven, the state target should be allocated among local governments within the state, or, where localities are highly fragmented, to regional governments.

To achieve the targets, local and regional governments would submit plans to the state using the strategies that best fit their communities. States would then rate those plans and provide greater financial support and regulatory relief to those places with better implementation plans. Meeting VMT targets provides the opportunity to achieve significant co-benefits (e.g. greater housing and transportation choice, fiscal savings, providing services in underserved neighborhoods), so the state may also rate local plans according to their achievement of these benefits. To help communities meet these targets, the state can provide grants and technical assistance to help localities develop realistic plans that score better and become eligible for greater state aid. New federal transportation policy (Green-TEA) could help by providing supportive policies and incentives.

As explained in Section 7.1.1., this system is similar to the one currently employed to meet air quality standards under the Clean Air Act (CAA). Under the CAA, metropolitan regions must inventory their emissions sources and develop plans to bring those emissions in line with clean air standards. For example, most metro regions already inventory their VMT and associated emissions. They also project future VMT and develop strategies to reduce emissions from both current and future auto trips.

Washington State's Commute Trip Reduction program employs a similar strategy and is focused explicitly on reducing single-occupant vehicle commutes and greenhouse gases.[52] To achieve these goals, the state has set targets for reductions in single occupant vehicle commutes and VMT per commuter. Local jurisdictions must then set goals that are at least equal to the state goals and create plans for achieving the target measures. This program is described on the web site as follows:

> 1) **Program goals.** This section establishes the goals and targets for the CTR program that every city and county shall seek to achieve at a minimum for the affected urban growth area within the boundaries of its official jurisdiction. Every two years, the state shall measure the progress of each jurisdiction and region toward their established targets for reducing drive-alone commute trips and commute trip vehicle miles traveled per CTR commuter. Local and regional goals and measurement methodologies shall be consistent with the measurement guidelines established by WSDOT and posted on the agency's web site.

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[52] See the Washington Department of Transportation Web site at http://apps.leg.wa.gov/WAC/default.aspx?cite=468-63-030

2) **Statewide minimum program goals and targets.** The goals and targets of local jurisdictions for their urban growth areas shall meet or exceed the minimum targets established in this section.

a) The first state goal is to reduce drive-alone travel by CTR commuters in each affected urban growth area. This will help urban areas to add employment and population without adding drive-alone commute traffic. The first state target based on this goal is a ten percent reduction from the jurisdiction's base year measurement in the proportion of single-occupant vehicle commute trips (also known as drive-alone commute trips) by CTR commuters by 2011.

b) The second state goal is to reduce emissions of greenhouse gases and other air pollutants by CTR commuters. The second state target based on this goal is a thirteen percent reduction from the jurisdiction's base year measurement in commute trip vehicle miles traveled (VMT) per CTR commuter by 2011.

3) **Local program goals and targets.** Local jurisdictions shall establish goals and targets that meet or exceed the minimum program targets established by the state. The goals and targets shall be set for the affected urban growth area in the city or county's official jurisdiction, and shall be targets for the year 2011 based on the base year measurement for the urban growth area.

a) Each local jurisdiction shall implement a plan designed to meet the urban growth area targets. Progress will be determined every two years based on the jurisdiction's performance in meeting its established drive-alone commute trips and VMT targets. Local jurisdictions shall establish base year values and targets for each major employer worksite in the jurisdiction. However, the targets may vary from major employer worksite to major employer worksite, based on the goals and measurement system implemented by the jurisdiction. Variability may be based on the following considerations:

### 7.2.2. Adopt State Transportation and Land Use Policies That Supports Climate Goals

***Guide Transportation Investments to Projects That Support the Creation of Walkable Communities, More Transportation Choices, and the Achievement of Climate Goals***

The prevailing method of transportation planning—trying to keep up with demand by simply "projecting and providing"—has proved to be both more expensive and less successful than many would wish. In spite of large transportation investments, congestion nationally continues to worsen year after year. Further, future projected needs far outstrip any reasonable estimates of available funds. Finally, beyond fiscal constraints, climate change, an aging population, changing market demand, and other macro-trends suggest that a continuation of strategies that rely nearly exclusively on automobile transportation is untenable.

Instead, states can work with localities and the public to identify future land use and transportation scenarios that provide a wide and suitable array of transportation choices, manage the growth of VMT and emissions, reduce household and government transportation expenses, and support greater access and mobility for all citizens. The California Department of Transportation is currently supporting this approach through its BluePrint project where localities proactively examine future growth scenarios and make investments to achieve the desired scenario. Similar processes have worked in Utah (Envision Utah) and Oregon (The LUTRAQ project). In these latter cases, the preferred future growth scenarios reduced vehicle miles of travel, created better traffic outcomes and saved infrastructure costs. Both studies are included in the literature reviewed above.

Once a future land use/transportation scenario is identified, states can then direct every new investment toward building that scenario. This is substantially different from the current process, because rather than simply responding to land use changes transportation investments now help to shape those changes in a way that leads to better outcomes. Investing in a specific vision for a region's or community's future will ensure that the future is more than just the sum of individual projects, and that development decisions and policies help meet economic, environmental, community, and fiscal goals. State policy changes that implement this approach include:

- A shared state and local vision of the future transportation system;
- Evaluating the full range of options and outcomes in a mode-neutral way, including system and demand management, land use, and alternative modes;
- A State transit village program to coordinate state policy for growing transit locations and identify future transit-oriented development (TOD) opportunities (e.g., New Jersey);
- State standards to allow roads to adapt to the surrounding land use and the adoption of context-sensitive design more broadly (many states, including Montana, Ohio, Massachusetts, Texas, and Washington);
- State access management policies that are consistent with the future transportation system (e.g., managing highway access for new developments to better manage traffic loads; leading examples include policies in Colorado, Maryland, Florida, Oregon, and Delaware);
- State connectivity policies that rely more on a larger number of smaller, interconnected road facilities, with accompanying state funding for smaller-scale roads;
- A Fix-it-First infrastructure policy (e.g., New Jersey's Fix-it-First program for transportation);
- Adoption of a "complete streets" policy and an emphasis on providing a variety of attractive transportation options to the maximum number of people (e.g., St. Louis and San Diego);
- Elimination of state restrictions that prohibit gasoline tax revenues from being spent on public transportation and other modes (most states do not have such prohibitions); and
- Requirements for developers to assess and mitigate climate impacts of large projects (e.g., Massachusetts[53]; King County, Washington[54]).

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[53] Massachusetts Executive Office of Energy and Environmental Affairs (2007), "MEPA Greenhouse Gas Emissions Policy and Protocol." http://www.mass.gov/envir/mepa/pdffiles/misc/ghgemissionspolicy.pdf.

[54] King County (2007), "Executive Order on the Evaluation of Climate Change Impacts through the State Environmental Policy Act." http://www.metrokc.gov/exec/news/2007/pdf/climateimpacts.pdf.

Also, with successful trials around the globe, roadway pricing strategies will likely become a key tool in managing traffic congestion and raising revenue in the U.S. States will play a key role in approving metropolitan pricing schemes, as will the federal and local governments. Such efforts can have a major impact on VMT reduction and funding alternatives, such as infill development, cycling and walking infrastructure, transit operations and capital, and other priorities.

### 7.2.3. Align State Spending With Climate and Smart Growth Goals

***Set Performance Standards for Discretionary and Formula-Allocated Spending, and Target Spending to Areas that Rank Better for Smart Growth***

States should ensure that funding programs support climate and VMT reduction goals and should adopt policies to reward local governments that help to meet such goals. States should begin by inventorying all available discretionary funds in such areas as housing, economic development, infrastructure, water and sewer, schools, transportation, state facilities, and recreation. These funds can then be allocated to localities according to their performance in meeting state goals. This inventory should include not only state funds, but also federal funds passed through the state over which the state has discretionary control. These discretionary funds, if thoroughly identified and pooled, can amount to a significant incentive for counties and municipalities. When Massachusetts employed this approach, discretionary funds totaled roughly $500 million within an annual state budget of $27 billion.

After completing its inventory of discretionary funds, the state should develop a coordinated investment approach that would tie funding to local performance on the state's priorities for transportation, housing, tax reduction, and climate. One mechanism for judging performance is a scorecard modeled on the Commonwealth Capital Fund in Massachusetts. This scorecard system awards points when local governments change their development rules and funding to promote more compact, mixed-use, walkable neighborhoods. Communities that score well receive access to some funding when the rule changes are made, and receive access to the larger, remaining portion of funding when new development projects are permitted—tightly linking spending with results.[55] These incentives have lead directly to hundreds of changes to local zoning in Massachusetts cities and towns. These changes contributed to increased production of multi-family housing units from 3,800 to more than 7,000 units annually.

Another state scorecard system is used by the California Infrastructure and Economic Development Bank's Infrastructure State Revolving Fund Program. It rates applications on a 200-point scale that gives substantial preference to projects that:

1) are located in or adjacent to already developed areas and in a jurisdiction with an approved General Plan Housing Element;
2) are located in or adjacent to and directly benefit areas with high unemployment rates, low median family income, declining or slow growth in labor force employment, and/or high poverty rates; and
3) improve the quality of life by contributing to public safety, health care, education, day care, greater use of public transit, or downtown revitalization.

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[55] For more information on Massachusetts' Commonwealth Capital Fund and its scorecard, please see: www.mass.gov/?pageID=gov3topic&L=2&L0=Home&L1=Smart+Growth&sid=Agov3.

Unlike a state's discretionary funds, "formula funds" are distributed to localities on the basis of a formula that is applied annually to a given funding stream (e.g., gas tax revenues, housing funds). Thus, each locality is guaranteed a share of this money. Without changing the geographic allocation of these funds, states can ensure that these dollars are invested in projects that contribute to meeting state goals. The top priorities should be to minimize long-term costs of maintenance and maximize the safety and security of existing roads, bridges, transit, water systems, and other critical community infrastructure. In doing so, the state gets the additional and climate-friendly outcome of making infill and redevelopment more attractive. Therefore, states can designate that a certain percentage of "formula-funded" transportation, school, housing, or other funds to go to the operation and maintenance of existing transportation, water, and wastewater infrastructure.

The remaining funds can be made available to projects that perform best with respect to meeting state goals. Projects within a locality should compete for these funds based on performance, without a predetermined water treatment technology or transportation mode. With this "means neutrality" built in, more innovative projects will be able to successfully compete and become established in the market.

### 7.2.4. Create Economic Development Incentives

***Modernize Incentives to Support Growth and Climate Goals***

The average state enables and oversees more than 30 different kinds of company-specific economic development incentives. Most are effectively as-of-right (rather than competitive or discretionary), and many are granted by local or regional bodies. While a few (e.g., brownfield remediation credits) are *de facto* limited primarily to developed areas, they are not officially linked to state land use policy or to transportation planning through enabling legislation. Very few state incentives are harnessed to facilitate shorter commutes, transit-oriented development, or other efficient practices.

Maryland's Smart Growth Areas Act explicitly seeks to better coordinate economic development with planning. Enacted in 1997, the law designates Priority Funding Areas (PFAs), defined as those areas that are already served by water and sewer infrastructure or are planned to receive infrastructure (both urban and rural). The state will spend infrastructure and economic development money only within these PFAs. Areas outside the PFAs are ineligible for state assistance in the form of infrastructure spending or economic development incentives; if development happens there, it will happen without help from the state. The law is one of several Maryland initiatives to preserve rural lands and revitalize cities and towns.

Illinois' Business Location Efficiency Incentive Act, enacted in 2005, gives a small additional corporate income tax credit under one common state incentive (Economic Development in a Growing Economy) if the job site is accessible by public transportation and/or proximate to affordable workforce housing.[56] Companies seeking the additional credit at sites that do not initially qualify can later qualify with a site remediation plan that includes measures such as an employer-assisted housing plan, shuttle services, pre-tax transit cards, or carpooling assistance.

By virtue of their statutory control over both state tax credits and the most common kinds of local incentives, such as property tax abatements, tax increment financing districts, and enterprise zones, states have an enormous amount of unrealized power to recast economic development as a tool for efficient growth and reduced VMT.

### 7.2.5. Eliminate Perverse Local Growth Incentives

***Reduce Competition Between Local Governments and Eliminate the "Fiscalization of Land Use" That Distorts Local Priorities***

Local governments rely upon a variety of state-regulated revenue streams to fund local public services. But state policies sometimes depress one stream (e.g., property taxes) while enabling another (e.g., local sales tax increments), giving local governments a fiscal incentive to avoid, for example, residential land use and instead subsidize big-box retail projects. The result of these decisions can be the concentration of jobs far from workers, under-provision of affordable housing and housing for families, and attempts to export negative impacts of development to neighboring jurisdictions.

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[56] SB2855, at http://www.ilga.gov/legislation/BillStatus.asp?DocNum=2885&GAID=8&DocTypeID=SB&LegId=23994&SessionID=50, promoted by a coalition of public interest organizations including Good Jobs First, Center for Neighborhood Technology, Chicago Metropolis 2020 and other groups.

It is difficult for local governments to address these issues on their own. Those that are friendly to family housing or affordable housing can become overwhelmed if their neighbors seek to block these housing types. Localities that do not aggressively zone for commercial land use risk being out-competed by neighbors that do. While local governments in a few metro areas, such as Minneapolis/St. Paul and the City of Charlottesville and Albemarle County, Virginia, have developed pacts to deter intraregional competition, this is relatively rare.

States can eliminate the perverse incentives that local governments face in the development market. In Massachusetts, local governments were reluctant to permit housing for families, fearing that an influx of children would add to the cost of education. The state now provides towns with a hold-harmless guarantee: if education costs rise, the state makes up the difference. In Arizona, local government retail incentive packages became so large and so frequent that the state passed a law prohibiting them in the Phoenix metro area. For many New England states, property taxes are the dominant funding source, and property tax reform is seen as the potential solution. In parts of the West where property tax caps are more common, sales taxes can be a driver of land use decisions, and reform efforts must focus on this dynamic.

According to the National Association of Industrial and Office Properties' (NAIOP) web site, where localities have taken steps to reduce competition for tax base the following lessons can be drawn[57]:

- In the Twin Cities Region in Minnesota, this technique has notably reduced disparities among the localities included in the pool concerning their assessed non-residential property values per capita. When this arrangement was put into effect in 1975, the greatest disparity was 50 to 1; today it is 12 to 1. It is not clear whether this technique has greatly reduced competition among adjacent or nearby localities for added non-residential development projects.32
- In the Dayton, Ohio, region, this technique has made it possible for multiple municipalities to cooperate in promoting the economic development of the entire region, including the provision of affordable housing and cultural facilities serving the entire region.
- In the Hackensack Meadows District, in New Jersey, this technique has made it possible for a regional body to develop a land-use plan that is rational from the broader perspective of an entire region, even though that region encompasses parts of 14 municipalities and two counties, without causing fiscal disadvantages to any of the those 16 legal entities.
- In Rochester, New York, the city is able to collect more funds from the local option sales tax that flows through the county government than it could if it charged that tax only within its own boundaries.

[57] http://www.naiop.org/governmentaffairs/growth/rtbrs.cfm.

## 7.3. Regional and Local Policy Recommendations

Many local governments are committing to action to reduce greenhouse gas emissions; more than 650 mayors have signed on to the U.S. Conference of Mayors' Climate Protection Agreement,[58] and about 400 have signed on as "Cool Mayors" with ICLEI's Mayors for Climate Protection program.[59] The Sierra Club, in partnership with King County, Washington; Fairfax County, Virginia; and Nassau County, New York, recently launched the "Cool Counties" campaign. To achieve their greenhouse gas reduction goals, these localities will have to include policies that reduce VMT. The following policies can help local governments reach the $CO_2$ reductions they want, while also creating and supporting strong, healthy, diverse communities where people have more choices in where they live and how they get around:

1) Change the development rules to modernize zoning and allow mixed-use, compact development;
2) Favor location-efficient and compact projects in the approval process;
3) Prioritize and coordinate funding to support infill development;
4) Make transit, pedestrians, and bikes an integral part of community development; and
5) Invest in civic engagement and education.

### 7.3.1. Change the Development Rules

***Examine the Rules and Regulations That Govern Development, and Determine if and how They Need to be Changed to Get Smart Growth That Reduces $CO_2$ Emissions***

As discussed in the State Policy Recommendations section, many communities want to create mixed-use neighborhoods, integrate new development with transit stops, allow more density and more compact neighborhoods, offer more types of housing to allow people of different income levels to live in the same neighborhood, or require sidewalks, bike lanes, and other bicyclist and pedestrian amenities. But many find that their development rules do not allow them to get the type of development they want. Sometimes a community may even develop a vision of what its residents want from development, only to find that it simply is not possible to fulfill the vision under the existing regulations. Part of the strategy for reducing $CO_2$ emissions from vehicles is to make it easier to build more location efficient, compact developments that allow people to choose walking, bicycling, or public transit.

To achieve that goal, communities should examine their development rules and determine if and how they need to be changed to meet smart growth, $CO_2$ reduction, and other community goals. Several tools, such as scorecards and zoning code audits, are available to help communities figure out what they need to change to get the kind of development they want.[60] Some opportunities for reform include:

- zoning codes;
- subdivision regulations;

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[58] As of August 2007; see http://usmayors.org/climateprotection/listofcities.asp for the list of signatories.
[59] See http://www.coolmayors.com/common/directory/browse_mayors.cfm?clientID=11061 for the list of mayors.
[60] See, for example, the policy and code audit tools from the Smart Growth Leadership Institute at http://www.sgli.org/implementation.html and samples of scorecards from around the country at http://www.epa.gov/smartgrowth/scorecards/.

- street design standards;
- parking standards;
- annexation rules;
- design guidelines; and
- any other regulation that affects the location and design of development.

Rarely do these regulations require a complete overhaul to make smart growth projects permissible "by right"; many times, it can be done with tools like area plans or overlay zones.

For example, Nashville/Davidson County, Tennessee, had subdivision regulations that applied to rural, suburban, and urban areas equally. Therefore, building more dense and compact development in the central city was not possible. With assistance from the Smart Growth Leadership Institute, the county revised its subdivision regulations so that different standards could be applied to different areas.[61] Now the county can preserve the character of its rural areas while permitting the vibrant development it wants in more urban areas.

Such regulatory reform efforts are largely responding to market demand that is strong across the nation. A recent national survey of developers found that more than 60 percent agreed with the following statement about compact, walkable development: "In my region there is currently enough market interest to support significant expansion of these alternative developments," with a high of 70 percent in the Midwest and a low of 40 percent in the South Central region.[62]

State and local governments should also find ways to expedite and reward exemplary projects that meet the U.S. Green Building Council's LEED for Neighborhood Development (LEED ND) certification standards, and consider adopting those standards as their own. Illinois, for example, just passed "The Green Neighborhood Grant Act," which is the first state legislation to tie LEED ND standards to financial incentives. The Illinois program authorizes the Department of Commerce and Economic Opportunity to issue Requests for Proposals (RFPs) from model development projects that have received LEED ND certification, and award up to three grants to reimburse up to 1.5 percent of the total development costs.

### 7.3.2. Favor Good Projects in the Approval Process

***Make It Easier, Faster, and More Cost Effective for Good Development Projects to Get Approved, and Offer Incentives and Flexibility to Get Better Development***

Once communities have reformed their regulations to allow good development, they should make it easier for that good development to be approved. Predictability in the development process is valuable to everyone concerned: developers, local government, and community members. Laying out the guidelines and rules for what the local government considers a "good" development project makes the process more predictable and fair, as does defining the benefits developers will get from meeting or exceeding the community's standards. Two main ways to favor good projects are to offer them flexibility and to speed the approval process.

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[61] See http://www.nashville.gov/mpc/subdivregs/intro.htm and http://www.sgli.org/communities.htm#nashville

[62] Jonathan Levine and Aseem Inam, "The Market for Transportation-Land Use Integration: Do Developers Want Smarter Growth than Regulations Allow?" *Transportation*, Volume 31, Number 4, November 2004.

Flexibility in meeting requirements gives developers room for innovation and creativity, as well as cost savings. If a development project meets or exceeds the community's goals and vision, the developer should be rewarded with, for example, a density bonus that allows them to build more in exchange for providing an amenity the community wants, like affordable housing. Alternatively, local governments can calculate the traffic reduction benefits of a development and adjust accordingly how much parking, road improvements, or air-quality mitigation the developer needs to deliver.

Developers tend to favor an approval process in which projects that follow certain guidelines or are located in targeted areas get streamlined or fast-tracked approvals. Communities might guarantee review of the project within a certain amount of time, or they might coordinate the various departments that need to review development proposals so that review happens quickly and smoothly. Of course, the process must include several opportunities for meaningful public input and review and must ensure compliance with other environmental safeguards.

Some communities do this by setting out specific desirable criteria; any development that meets these criteria gets a fast track to approval. With the advent of the LEED-ND green development guidelines, communities have a good starting point for setting standards to define walkable, environmentally responsible neighborhoods.

In Austin, Texas, the city developed a matrix of smart growth criteria to help it analyze development proposals within areas where it wants to encourage development. The matrix measures how well the project meets the city's goals, including the location of the project, its mix of uses, its proximity to public transit, its pedestrian-friendly design, compliance with nearby neighborhoods' plans, and other policy priorities, including tax base increases. For projects that score above a certain level on the matrix, the city will waive some fees or invest public money in infrastructure for the development.[63]

In other places, an outside organization plays a similar role, setting up a list of criteria and offering public support for projects that meet those criteria. For example, the Greenbelt Alliance in the San Francisco Bay Area will endorse developments that are "pedestrian-oriented and transit accessible, use land efficiently, and provide affordable housing."[64] The Greenbelt Alliance will send a letter of support to the appropriate officials and actively support a project at public hearings if requested. Similar programs, with varying degrees of endorsement, are run through alliances in many other regions.[65] While this outside support doesn't guarantee a faster process, the stamp of approval from a neutral entity can help some projects get approved.

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[63] See http://www.ci.austin.tx.us/smartgrowth/default.htm.

[64] See http://www.greenbelt.org/whatwedo/prog_cdt_index.html.

[65] See, for instance, the Vermont Smart Growth Collaborative's Housing Endorsement Program (http://www.vtsprawl.org/Initiatives/sgcollaborative/VSGC_housingendorsement.htm) or the Urban Land Institute-supported Smart Growth Alliances Information Network. (http://www.uli.org/Content/NavigationMenu/MyCommunity/SmartGrowth/SmartGrowthAllianceInformationNetwork/Smart_Growth_Allianc.htm).

### 7.3.3. Prioritize and Coordinate Funding to Support Infill Development

***Find Funding Sources to Support Infill Development, Coordinate Funding to Get the Most Impact, and Prioritize Infrastructure Projects to Determine Where the Investment will Do the Most Good***

Just as at the federal and state levels, local governments should prioritize funding, including infrastructure spending, to support development that helps reduce $CO_2$ emissions and meets other community, economic, and environmental goals. By directing infrastructure funds to infill projects, whether to repair existing infrastructure or build new facilities, the community is investing in the type of development that can help reduce $CO_2$ emissions by creating more options for residents. Just as importantly, it is not subsidizing development in far-flung areas that will generate more vehicle trips. This money is a public investment, and it should be spent wisely and with the goal of doing the most good for the most people. As the Metropolitan Council of the Twin Cities region of Minnesota puts it:

> For the metropolitan transit and transportation system, putting growth where the infrastructure to support it already exists means roads that *don't have to be built.* Providing transportation options that include fast, convenient transit services means freeway lanes that *don't have to be added.* And, where new infrastructure is necessary, investments in more connected land-use patterns will be the most fiscally responsible use of limited public resources for transportation.[66] [emphasis theirs]

Scorecards are useful to set priorities for public spending. Similar to the scorecards mentioned previously in this chapter, communities can set up criteria based on location in an area designated for growth; proximity to transit, housing, workplaces, and other amenities; need for new infrastructure; and accommodation of automobiles, pedestrians, bicyclists, and transit. Infrastructure projects and other expenditures that score highly on the scorecard get priority, or get more public funding compared to projects that score poorly.

To get the most from their investments in infrastructure, transit, housing, and other expenditures, local governments should coordinate their land use policies with these investments. This means directing development to areas around transit stations, sharing parking among different uses, building new schools in places easily accessible to the neighborhoods they will be serving, and so forth.

### 7.3.4. Make Transit, Pedestrians, and Bikes an Integral Part of Community Development

***Create a Comprehensive Vision and Plan for Creating Safe and Accessible Routes, Networks, Environments, and Linkages to Destinations. Rewrite Rules as Necessary, and Invest in Supportive Infrastructure.***

If communities make it easier for people to walk, bike, or ride transit, they create new options for people besides driving. Making transit, bike, and pedestrian amenities part of planning guidelines creates predictability for developers and can help reduce traffic from new development, which is

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[66] *2030 Regional Development Framework*, Metropolitan Council, pp. 6-7, adopted January 14, 2004, amended December 14, 2006, http://www.metrocouncil.org/planning/framework/Framework.pdf.

a major concern of many of those who live in adjacent neighborhoods. Streets that are built with not only cars, but also bicycles, transit, and pedestrians in mind—often known as "complete streets"—are safer and make people feel more comfortable walking or biking. They are also often more attractive, with shade trees, benches, and other amenities. And they provide options for people who can't or choose not to drive, including children, older people, and people with disabilities.

Localities should adopt complete streets policies and design guidelines to create safe and welcoming environments for pedestrians, cyclists, and transit users. These policies require the accommodation of all users of the right of way, and set out new procedures for ensuring that construction, reconstruction, and maintenance projects balance the needs of all users. Accommodating new, walkable development on land that once held dead shopping centers or factories, or creating transit-oriented developments at rail stations, is likely to require investments in building or retrofitting a street network for pedestrians and cyclists.[67]

A great example of a place that has put all the elements together is Arlington County, Virginia, a suburb of Washington, D.C. Arlington County's master transportation plan includes elements for transit, bicycling, and walking.[68] The county has two subway lines, part of Washington's Metrorail system, and numerous bus routes. It has coordinated its land use with these transit investments, concentrating development along the subway lines and tailoring bus lines to key corridors. The county has emphasized safe and appealing walking and biking environments, putting in bike lanes, sidewalks, crosswalks (many with "countdown" pedestrian signals to let people know how much time they have left to cross the street), and bike and walking paths that connect to trails that go throughout the Washington metropolitan region. The county has also brought in car-sharing services to make it easier for residents to own one car instead of two, or to go without a car.

As a result of having all these transportation options, Arlington has some of the highest rates in the country of commuting by means other than personal automobile. Thirty-nine percent of Arlington residents commute by public transportation, twice the national average, and 6 percent walk to work, well above the national average of 1 percent.[69] The numbers are even higher in the subway corridors; in the Rosslyn-Ballston corridor, along Metrorail's Orange Line, 38 percent of residents who live within half a mile of a station take transit to work, and 73 percent of riders using these Metrorail stations walk to the stations. The foot traffic has fostered a lively commercial, retail, and residential corridor that comprises only 7.6 percent of the county's land area, yet produces about a third of its real estate tax revenue. Meanwhile, automobile traffic has been below projections as county population has grown, showing the benefits of these transportation options not only for the people who choose to bike, walk, or take transit, but also for those who drive.

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[67] See www.completestreets.org.

[68] See http://www.arlingtonva.us/Departments/EnvironmentalServices/dot/planning/mplan/MasterPlans.aspx for a copy of the master plan.

[69] Arlington Master Transportation Plan – Second Draft, Transportation Demand Management Element – November 2006, p. 9.

### 7.3.5. Invest in Civic Engagement and Education

***Engage and Educate Citizens in Visioning Exercises, and Require Opportunities for Meaningful Citizen Participation in Development Decision-Making***

For plans to be as successful as possible, the people who will be living and working in the community must be involved in creating them. This means that residents have to have opportunities to learn about the issues and give their input on decision-making. Education might mean public meetings, gathering and publishing data and maps in an easily understood format that's relevant to people's lives, or keeping a Web site up to date on local development issues. With a foundation of basic knowledge about these issues, people are better equipped to participate in development decisions and in guiding the future of their community. When residents are engaged in the decision-making process from the beginning and feel like their concerns and ideas are being heard and considered, they are less likely to fight new development. The extra money spent on these education and engagement efforts pays off in the long run in better development projects that move through the process more smoothly.

One popular form of engagement is a visioning exercise, usually held on a regional or local scale. Participants review various scenarios for the future of the region or community and choose the one that they prefer. Usually there is a "business as usual" scenario that shows how continuing along the current path will affect open space, traffic congestion, development, air and water quality, and other quality of life issues. Other scenarios illustrate what the future could look like with denser development, more transportation options, and development directed to certain areas to preserve open space.

Visioning exercises have been conducted all over the country. One of the best examples is the Sacramento Region's *Blueprint Transportation and Land Use Study*, which used an extensive public outreach process, cutting-edge Internet-accessible planning software, and a detailed business-as-usual baseline growth forecast to help participants to explore alternative growth scenarios through 2050. The adopted preferred scenario features sophisticated infill development and transportation investments that will produce 12.3 fewer daily vehicle-miles of travel per household by 2050, a 27 percent reduction below the baseline. Other well-known examples include Envision Utah, which began in 1997 and was the first large-scale scenario planning exercise in the nation, as well as Louisiana Speaks, which was launched to help coastal communities craft redevelopment plans after the devastation from Hurricanes Katrina and Rita and attracted over 27,000 participants.

Visioning exercises create general principles and strategies for development, but the public should also be engaged in making decisions on specific development projects. They need to be involved from the beginning for their input to be meaningful, and they need to know that their ideas and concerns are being listened to and taken seriously, even if they don't end up being incorporated into the project. Some of the tools communities use to get citizen input are design workshops, charrettes, public surveys, or public meetings.

In a planning ordinance approved in 2001, the town of Davidson, North Carolina, requires new development projects to hold a charrette to get public input. These workshops allow the developer and the town's residents to understand each other's concerns and goals and to work together to make sure the development meets the community's needs. The process gives citizens

the chance to have their voices heard, and it lets developers deal with problems before they can hold up the project in the approval process. Gathering public support at this early stage makes the approval process smoother for developers. Davidson has found that holding these *charrettes* helps preserve its small-town character and makes it easier to achieve its goal of making bicycling and walking safer and more pleasant.

## 7.4. Developing a Comprehensive Policy Package

Such a comprehensive overhaul of America's development processes will be a mighty challenge. But it is on the same ambitious scale as other proposals that are being considered in the climate change debate, including efforts to switch to renewable fuels, dramatically increase vehicle efficiency, end oil imports from hostile nations, or renew investment in nuclear power.

The fact is, no gigaton of reduction will come very easily, and few methods are likely to take advantage of consumer demand as much as those discussed in this book. In fact, many of the reforms discussed here focus on making government rules and regulations more flexible to give people more of what they want. Also, most of the communities that have adopted these reforms have done so for a wide variety of self-interested reasons, like traffic management or financial rewards, and not because they wished to reduce greenhouse gas emissions. We are confident that these improvements to the built environment can offer tremendous win-win benefits, and hope that these types of policies do get implemented across the nation and the world. They should become a sensible complement to any other climate policies that focus on energy, vehicles, power plants, or other strategies.

# 8. Conclusion

With regard to urban development and travel demand management, this publication asks and answers three critical questions facing the urban planning profession, land development community, and federal, state, and local policy makers:

- What reduction in vehicle miles traveled (VMT) is possible in the United States with compact development rather than continuing urban sprawl?
- What reduction in $CO_2$ emissions will accompany such a reduction in VMT?
- What policy changes will be required to shift the dominant land development pattern from sprawl to compact development?

The answer to the first question is a 20 to 40 percent reduction in VMT for each increment of new development or redevelopment, depending on the degree to which best practices are adopted (see Chapter 3). The answer to the second question is a 7 to 10 percent reduction in total transportation $CO_2$ emissions by 2050 relative to continuing sprawl (see section 1.7). The answer to the third question is a set of dramatic policy changes at all three levels of government (see Chapter 7).

Unlike other vehicle emissions, $CO_2$ emissions have never been regulated. Given the difficulty of changing longstanding policies, development patterns and, ultimately, lifestyles, is the 7 to 10 percent reduction in $CO_2$ emissions worth the effort? The answer, we believe, is "yes," for three primary reasons:

- The U.S. transportation sector cannot reach a sustainable level of $CO_2$ emissions through vehicle and fuel technology improvements alone. It also needs to reduce VMT, as the third leg supporting the policy stool (see Chapter 2).
- The shift from sprawl to compact development will have many other economic, environmental, and quality-of-life benefits, so any "costs" of this $CO_2$ reduction strategy will be offset by additional quantifiable benefits (see sections 1.5 and 1.6).
- Reductions in VMT and $CO_2$ emissions with compact development are sizable and long lasting compared to reductions achievable with other available actions (see section 1.7 and Chapter 3).
- Compact development provides an insurance policy against the worst effects of climate change and oil price spikes. In the worst case, current or future residents of compact development will have a variety of viable transportation options, while the residents of sprawl will not.

# References

## *Executive Summary*


Bartholomew, K. "Integrating Land Use Issues into Transportation Planning: Scenario Planning—Summary Report," 2005 http://content.lib.utah.edu/cgi-bin/showfile.exe?CISOROOT=/ir-main&CISOPTR=99&filename=189.pdf.

———. "Land Use-Transportation Scenario Planning: Promise & Reality." *Transportation,* Vol. 34(4), 2007, pp. 397–412.

Energy Information Administration (EIA). *Annual Energy Outlook 2007.* Washington, D.C.: U.S. Department of Energy, http://www.eia.doe.gov/oiaf/aeo/index.html.

Ewing, R., R. Pendall, and D. Chen. *Measuring Sprawl and Its Impact.* Washington, D.C.: Smart Growth America/U.S. Environmental Protection Agency, 2002.

———. "Measuring Sprawl and Its Transportation Impacts." *Journal of the Transportation Research Board,* Vol. 1832, 2003, pp. 175–183.

Federal Highway Administration (FHWA). "Vehicle Registrations, Fuel Consumption, and Vehicle Miles of Travel as Indices," *Highway Statistics 2005.* Washington, D.C.: U.S. Department of Transportation, 2005, http://www.fhwa.dot.gov/policy/ohim/hs05/htm/mvfvm.htm.

Frank, L., S. Kavage, and B. Appleyard. "The Urban Form and Climate Change Gamble." *Planning,* Vol. 73, No. 8, August/September 2007, pp. 18–23.

Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2007: The Physical Science Basis, Summary for Policymakers.* Working Group I contribution of the Intergovernmental Panel on Climate Change: Fourth Assessment Report, 2007, www.ipcc.ch/.

Lincoln Institute of Land Policy. *Visualizing Density.* Cambridge, Massachusetts, 2007, www.lincolninst.edu/subcenters/VD/.

Moudon, A.V. et al. "Effects of Site Design on Pedestrian Travel in Mixed-Use, Medium-Density Environments." *Transportation Research Record.* Vol. 1578, 1997, pp. 48–55.

Nelson, A.C. "Leadership in a New Era." *Journal of the American Planning Association.* Vol. 72, No. 4, 2006, pp. 393–407.

Socolow, R. and S. Pacala. "A Plan to Keep Carbon in Check." *Scientific American.* September 2006, pp. 50–57.

Smart Growth Network. *This Is Smart Growth.* Washington, D.C.: International City/County Management Association (ICMA) and the U.S. Environmental Protection Agency (EPA), 2006, http://www.smartgrowth.org/library/articles.asp?art=2367.

Walters, J., R. Ewing, and E. Allen. "Adjusting Computer Modeling Tools to Capture Effects of Smart Growth." *Transportation Research Record.* Vol. 1722, 2000, pp. 17–26.

## Chapter 1: Introduction

Air Resources Board (ARB). *Proposed Early Actions to Mitigate Climate Change in California.* Sacramento: California Department of Environmental Quality, April 30, 2007, www.climatechange.ca.gov/climate_action_team/reports/2007-04-20_ARB_early_action_report.pdf.

American Association of State Highway Transportation Officials (AASHTO). *A New Vision for the 21st Century*, July 2007, www.transportation1.org/tif5report/TIF5.pdf.

American Planning Association. *Planning for Smart Growth: 2002 State of the States.* Chicago, February 2002.

Anderson, L. "Baby Boomers: Play Down Age, Play Up Options." *Builder News,* December 2004, http://www.buildernewsmag.com/viewnews.pl?id=175.

Bayer, A. and L. Harper. *Fixing to Stay: a National Survey of Housing and Home Modification Issues.* Washington, D.C.: American Association of Retired Persons (AARP), May 2000.

Belden Russonello & Stewart. *National Survey on Growth and Land Development.* Washington, D.C.: Smart Growth America, September 2000, www.smartgrowthamerica.org/poll.pdf.

———. *Americans' Attitudes Toward Walking and Creating Better Walking Communities.* Washington, D.C.: Surface Transportation Policy Project, April 2003, www.transact.org/library/reports_pdfs/pedpoll.pdf.

———. *National Survey on Communities.* Washington, D.C.: National Association of Realtors and Smart Growth America, October 2004, www.brspoll.com/Reports/Smart%20Growth.pdf.

Burchell, R. et al. *Costs of Sprawl—2000.* Washington, D.C.: Transportation Research Board, National Academy Press, 2002.

Carruthers, J.I. and G.F. Ulfarsson. "Urban Sprawl and the Cost of Public Services." *Environment and Planning B,* Vol. 30, Issue 4, 2003, pp. 503–522.

Cervero, R. et al. *Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects.* TRCP Report 102, Washington, D.C.: Transportation Research Board, 2004.

Climate Action Team. *Climate Action Team's Proposed Early Actions to Mitigate Climate Change in California—Draft for Public Review.* Sacramento: California Department of Environmental Quality, April 30, 2007, www.climatechange.ca.gov/climate_action_team/reports/2007-04-20_CAT_REPORT.PDF.

DeCicco, J. and F. Fung. *Global Warming on the Road: The Climate Impact of America's Automobiles.* Washington, D.C.: Environmental Defense, 2006.

Energy Information Administration (EIA). *Emissions of Greenhouse Gases in the United States 2005.* Washington, D.C.: U.S. Department of Energy, 2006.

———. *U.S. Carbon Dioxide Emissions from Energy Sources: 2006 Flash Estimate.* Washington, D.C.: U.S. Department of Energy, 2007a.

———. *International Energy Review 2007.* Washington, D.C.: U.S. Department of Energy, 2007b.

Environmental Protection Agency (EPA). "National Emissions Inventory (NEI) Air Pollutant Emissions Trends Data." Washington, D.C., undated, www.epa.gov/ttn/chief/trends/.

———. "Energy." *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2005.* Washington, D.C., 2007, http://epa.gov/climatechange/emissions/usinventoryreport.html.

Envision Utah. *Quality Growth Strategy and Technical Review.* Salt Lake City, Utah, January 2000.

Eppli, M. and C. Tu. "Market Acceptance of Single-Family Housing in Smart Growth Communities." Washington, D.C.: Environmental Protection Agency, as reported in *On Common Ground,* Summer 2007, p. 55, http://www.realtor.org/smart_growth.nsf/docfiles/ocgsummer07.pdf/$FILE/ocgsummer07.pdf.

———. *Valuing the New Urbanism.* Washington, D.C.: ULI–the Urban Land Institute, 1999.

Ewing, R. "Is Los Angeles–Style Sprawl Desirable?" *Journal of the American Planning Association,* Vol. 63, 1997, pp. 107–126.

Ewing, R., S.J. Brown, and A. Hoyt. "Traffic Calming Revisited." *ITE Journal*, November 2005, pp. 22–28.

Ewing, R., R. Pendall, and D. Chen. *Measuring Sprawl and Its Impact.* Washington, D.C.: Smart Growth America/ U.S. Environmental Protection Agency, 2002.

Federal Highway Administration (FHWA). "Vehicle Registrations, Fuel Consumption, and Vehicle Miles of Travel as Indices." *Highway Statistics 2005,* Washington, D.C.: U.S.

Department of Transportation, 2005, http://www.fhwa.dot.gov/policy/ohim/hs05/htm/mvfvm.htm.

Fulton, W., R. Pendall, M. Nguyen, and A. Harrison. "Who Sprawls Most? How Growth Patterns Differ Across the U.S." Washington, D.C.: Brookings Center on Urban and Metropolitan Policy, 2001.

Goldberg, D. "The Pulse at the Polls." *On the Ground*, Summer 2007, pp. 6–13.

Gordon, P. and H. Richardson. "Are Compact Cities a Desirable Planning Goal?" *Journal of the American Planning Association*, Vol. 63, 1997, pp. 95–106.

He, W., M. Sengupta, V.A. Velkoff, and K.A. DeBarros. *65+ in the United States: 2005.* Washington, D.C.: U.S. Census Bureau, 2006, www.census.gov/prod/2006pubs/p23-209.pdf.

Hu, P.S. and T.R. Reuscher. *Summary of Travel Trends: 2001 National Household Travel Survey.* Washington, D.C.: Federal Highway Administration, 2004, http://nhts.ornl.gov/2001/pub/STT.pdf.

Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2007: The Physical Science Basis: Summary for Policymakers.* Working Group I contribution of the Intergovernmental Panel on Climate Change: Fourth Assessment Report, 2007a, http://www.ipcc.ch/.

———. *Climate Change 2007: Climate Change 2007: Impact, Adaptation and Vulnerability, Summary for Policymakers.* Working Group II contribution of the Intergovernmental Panel on Climate Change: Fourth Assessment Report, 2007b, http://www.ipcc.ch/

———. *Climate Change 2007: Climate Change 2007: Mitigation of Climate Change, Summary for Policymakers.* Working Group III contribution of the Intergovernmental Panel on Climate Change: Fourth Assessment Report, 2007c, http://www.ipcc.ch/

Kimley-Horn and Associates et al. "Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities-Proposed Recommended Practice." Washington, D.C.: Institute of Transportation Engineers, 2006, www.ite.org/bookstore/RP036.pdf.

Kirby, S. and M. Hollander. *Consumer Preferences and Social Marketing Approaches to Physical Activity Behavior and Transportation Choices*, prepared as a resource paper for *Does the Built Environment Influence Physical Activity? Examining the Evidence— Special Report 282*, January 2005, http://trb.org/downloads/sr282papers/sr282KirbyHollander.pdf.

Leinberger, C. *Back to the Future: The Need for Patient Equity in Real Estate Development Finance.* Washington, D.C.: Brookings Institution, January 2007.

Levine, J., A.Inam, and G. Tong. "A Choice-Based Rationale for Land Use and Transportation Alternatives—Evidence from Boston and Atlanta." *Journal of Planning Education and Research*, Vol. 24, No.3, 2005, pp. 317–330.

Lincoln Institute of Land Policy. *Visualizing Density.* Cambridge, Massachusetts, 2007, www.lincolninst.edu/subcenters/VD/.

Logan, G. "The Market for Smart Growth," presented at the U.S. EPA High-Production Builder Conference, Robert Charles Lesser & Co., LLP, January 31, 2007.

Mathew Greenwald & Associates. *These Four Walls . . . Americans 45+ Talk About Home and Community.* Washington, D.C.: American Association of Retired Persons (AARP), May 2003.

Mui, S., J. Alson, B. Ellies, and D. Ganss. *A Wedge Analysis of the U.S. Transportation Sector.* Washington, D.C.: Transportation and Climate Division, U.S. Environmental Protection Agency, 2007.

Myers, D. and E. Gearin. "Current Preferences and Future Demand for Denser Residential Environments." *Housing Policy Debate*, 2001, pp. 633–659.

Myers, P. "Livability at the Ballot Box: State and Local Referenda on Parks, Conservation, and Smarter Growth, Election Day 1998." Washington, D.C.: Brookings Center on Urban and Metropolitan Policy, 1999.

Myers, P. and R. Puentes. "Growth at the Ballot Box: Electing the Shape of Communities in November 2000." Washington, D.C.: Brookings Center on Urban and Metropolitan Policy, 2001.

National Association of Homebuilders (NAHB). "Vanilla Not a Favorite Flavor of Generation X Home Buyers." *Nation's Building News*, July 19, 2004, http://www.nbnnews.com/NBN/issues/2004-07-19/Design/index.html.

Nelson, A.C. "Leadership in a New Era." *Journal of the American Planning Association*, Vol. 72, No. 4, 2006, pp. 393–407.

"New Urban Projects on a Neighborhood Scale in the United States." *New Urban News*, December 2003.

Papas, M.A., A.J. Alberg, R. Ewing, K.J. Helzlsouer, T.L. Gary, and A.C. Klassen. "The Built Environment and Obesity: A Review of the Evidence." *Epidemiologic Reviews*, 2007, in press.

Pew Center on Global Climate Change. "What's Being Done in Congress." Washington, D.C., July 2007, www.pewclimate.com/what_s_being_done/in_the_congress/.

Pew Research Center. "47-Nation Pew Global Attitudes Survey." Global Attitudes Project, Washington, D.C., June 27, 2007, http://pewglobal.org/reports/pdf/256.pdf.

Pickrell, D. *Fuel Options for Reducing Greenhouse Gas Emissions from Motor Vehicles.* Washington, D.C.: U.S. Department of Transportation, 2003, http://climate.dot.gov/docs/fuel.pdf.

Pisarski, A.E. *Travel Behavior Issues in the 90s.* Washington, D.C.: Federal Highway Administration, 1992, p. 10.

Robaton, A. "Lifestyle Centers Compete for Retailers." *Shopping Centers Today*, February 2005, http://www.icsc.org/srch/sct/sct0205/cover_3.php.

Schrank, D. and T. Lomax. *The 2005 Urban Mobility Report.* College Station: Texas Transportation Institute, 2005, http://mobility.tamu.edu/ums/.

Smart Growth Network. *This Is Smart Growth.* Washington, D.C.: International City/County Management Association (ICMA) and the U.S. Environmental Protection Agency (EPA), 2006, http://www.smartgrowth.org/library/articles.asp?art=2367.

Sobel, L. "Smart Growth: A Growing Real Estate Niche," presentation at 5th Annual New Partners for Smart Growth Conference, January 27, 2006, Denver, Colorado, www.cmcgc.com/media/handouts/260126/FRI-PDF/210-Sobel.pdf.

Socolow, R. and S. Pacala. "A Plan to Keep Carbon in Check." *Scientific American*, September 2006, pp. 50–57.

Surface Transportation Policy Project (STPP). *Aging Americans: Stranded without Options.* Washington, D.C., April 2004.

ULI–the Urban Land Institute and PricewaterhouseCoopers LLP. *Emerging Trends in Real Estate 2005.* Washington, D.C.: ULI–the Urban Institute, 2005.

———. *Emerging Trends in Real Estate 2006.* Washington, D.C., 2006.

———. *Emerging Trends in Real Estate 2007.* Washington, D.C., 2007.

U.S. Census Bureau. "U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin." Washington, D.C., 2004, www.census.gov/ipc/www/usinterimproj/.

U.S. Climate Action Partnership (USCAP). *A Call for Action.* Washington, D.C., January 2007, www.us-cap.org/USCAPCallForAction.pdf.

U.S. Conference of Mayors. *U.S. Conference of Mayors Climate Protection Agreement.* Washington, D.C., 2007, www.usmayors.org/climateprotection/agreement.htm.

Victoria Transport Policy Institute. "Transportation Elasticities: How Prices and Other Factors Affect Travel Behavior." Victoria, British Columbia, March 7, 2007, www.vtpi.org/tdm/tdm11.htm.

## Chapter 2: The VMT/$CO_2$/Climate Connection

Barnett, J. and W. Adger. "Climate Dangers and Atoll Countries." *Climatic Change*, Vol. 61, 2003, pp. 321–337.

Department for Environment, Food, and Rural Affairs (DEFRA). *Avoiding Dangerous Climate Change* (eds. H.J. Schellnhuber, W. Cramer, N. Nakicenovich, T. Wigley, and G. Yohe), Cambridge, United Kingdom: Cambridge University Press, 2006, www.defra.gov.uk/environment/climatechange/research/dangerous-cc/index.htm.

Energy Information Administration (EIA). *Annual Energy Outlook 2007.* Washington, D.C.: U.S. Department of Energy, 2007, http://www.eia.doe.gov/oiaf/aeo/index.html.

European Commission. "Limiting Global Climate Change to 2 degrees Celsius: The way ahead for 2020 and beyond, Impact Assessment." Memo/07/16, January 10, 2007, http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/07/16.

Ewing, R. and R. Cervero. "Travel and the Built Environment." *Transportation Research Record*, Vol. 1780, 2001, pp. 87–114.

Ewing, R., M. DeAnna, and S. Li. "Land Use Impacts on Trip Generation Rates." *Transportation Research Record*, Vol. 1518, 1996, pp. 1–7.

Goddard Institute for Space Studies. "2006 Was Earth's Fifth Warmest Year." February 8, 2007, http://www.nasa.gov/centers/goddard/news/topstory/2006/2006_warm.html.

Greenough, G., M. McGeehin, S. Bernard, J. Trtanj, J. Riad, and D Engelberg. "The Potential Impacts of Climate Variability and Change on Health Impacts of Extreme Weather Events in the United States." *Environmental Health Perspectives*, Vol 109, 2001, pp. 191–198.

Hegerl, G., T. Crowley, M. Allen, W. Hyde et al. "Detection of Human Influence on a New, Validated 1500-Year Temperature Reconstruction." *Journal of Climate*, Vol. 20, 2007, pp. 650–666.

Helme, N. and J. Schmidt. "Greenhouse Gas Stabilization Targets: Near-Term Implications for the U.S." 2007, http://www.ccap.org/domestic/documents/HelmeSchmidtTargetsPresentationCPI2.pdf.

HM Treasury. *Stern Review on the Economics of Climate Change*, 2006, www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm.

Höhne, N., D. Phylipsen, and S. Moltmann. *Factors Underpinning Future Action: 2007 Update.* Ecofys, 2007, http://unfccc.int/resource/docs/2007/smsn/ngo/026c.pdf.

Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2007: The Physical Science Basis, Summary for Policymakers.* Working Group I contribution of the Intergovernmental Panel on Climate Change: Fourth Assessment Report, 2007a, www.ipcc.ch/.

———. *Climate Change 2007: Impact, Adaptation and Vulnerability, Summary for Policymakers.* Working Group II contribution of the Intergovernmental Panel on Climate Change: Fourth Assessment Report, 2007b, www.ipcc.ch/.

———. *Climate Change 2007: Climate Change 2007: Mitigation of Climate Change, Summary for Policymakers.* Working Group III contribution of the Intergovernmental Panel on Climate Change: Fourth Assessment Report, 2007c.
http://www.ipcc.ch/

Meinshausen, M. "What does a 2°C target mean for greenhouse gas concentrations? A brief analysis based on multi-gas emission pathways and several climate sensitivity uncertainty estimates." In *Avoiding Dangerous Climate Change*, Cambridge, United Kingdom: Cambridge University Press, 2006, pp. 265–280.

Meinshausen, M. and M.G. J. den Elzen. *Meeting the EU 2°C Climate Target: Global and Regional Emission Implications.* Bilthoven: Netherlands Environmental Assessment Agency, 2005.

National Climate Data Center. *2006 Annual Climate Review: U.S. Summary.* Washington, D.C.: National Oceanic and Atmospheric Administration, June 21, 2007, http://www.ncdc.noaa.gov/oa/climate/research/2006/ann/us-summary.html#temp.

Natural Resources Defense Council (NRDC). *Polar Action Guide.* Washington, D.C., undated.

New England Governors/Eastern Canadian Premiers. "Climate Change Action Plan 2001," 2001, www.negc.org/documents/NEG-ECP%20CCAP.PDF.

Polzin, S.E. *The Case for Moderate Growth in Vehicle Miles of Travel: A Critical Juncture in U.S. Travel Behavior Trends.* Washington, D.C.: U.S. Department of Transportation, 2006.

Reuters. "Industrial nations agree step to new climate pact," August 31, 2007, http://www.reuters.com/article/topNews/idUSL3069978520070831?feedType=RSS&feedName=topNews.

Schipper, L. "Automobile Fuel; Economy and CO2 Emissions in Industrialized Countries: Troubling Trends through 2005/6," paper prepared for the 2007 Annual Meeting of the Transportation Research Board, World Resources Institute, Washington, D.C., August 2007.

Schwarzenegger, A. Executive Order S-3-05, 2005, www.governor.ca.gov/state/govsite/gov_htmldisplay.jsp?BV_SessionID=@@@@@1148099866.1187065401@@@@@&BV_EngineID=cccdaddljehkekmcfngcfkmdffidfng.0&iOID=69591&sTitle=Executive+Order+S-3-05&sFilePath=/govsite/executive_orders/20050601_S-3-05.html&sCatTitle=Exec+Order.

———.Executive Order S-01-07, 2007, http://gov.ca.gov/index.php?/executive-order/5172/.

U.S. Congress. "H.R. 6, Renewable Fuels, Consumer Protection, and Energy Efficiency Act of 2007 (Engrossed Amendment as Agreed to by Senate)," http://thomas.loc.gov/cgi-bin/bdquery/z?d110:h.r.00006.

## *Chapter 3: The Urban Development/VMT Connection*

1000 Friends of Oregon. *Making the Land Use, Transportation, Air Quality Connection: Analysis of Alternatives.* Vol. 5, Portland, Oregon, 1996, http://www.onethousandfriendsoforegon.org/resources/lut_vol5.html.

———. *Making the Connections: A Summary of the LUTRAQ Project.* Portland, Oregon, 1997.

Allen, E. and F.K. Benfield. *Environmental Characteristics of Smart Growth Neighborhoods, Phase II: Two Nashville Neighborhoods.* Washington, D.C.: Natural Resources Defense Council, February 2003.

Badland, H. and G. Schofield. "Transport, Urban Design, and Physical Activity: An Evidence-Based Update." *Transportation Research Part D*, Vol. 10, 2005, pp. 177–196.

Badoe, D.A. and E.J. Miller. "Transportation-Land-Use Interaction: Empirical Findings in North America, and Their Implications for Modeling." *Transportation Research Part D*, Vol. 5, 2000, pp. 235–263.

Baltimore Metropolitan Council. 2001 Travel Survey. **[please complete this reference (which is cited as the source of Figure 3.2)]**

Bartholomew, K. "Integrating Land Use Issues into Transportation Planning: Scenario Planning—Summary Report," 2005, http://content.lib.utah.edu/cgi-bin/showfile.exe?CISOROOT=/ir-main&CISOPTR=99&filename=189.pdf.

———. "Land Use-Transportation Scenario Planning: Promise & Reality." *Transportation*, Vol. 34(4), 2007, pp. 397–412.

Beimborn, E., R. Kennedy, and W. Schaefer. *Inside the Blackbox: Making Transportation Models Work for Livable Communities.* Washington, D.C.: Citizens for a Better Environment and the Environmental Defense Fund, undated, http://ctr.utk.edu/TNMUG/misc/blackbox.pdf.

Boarnet, M.G., E.J. Kim, and E. Parkany. "Measuring Traffic Congestion." *Transportation Research Record*, Vol. 1634, 1998, pp. 93–99.

Cambridge Systematics. "The Effects of Land Use and Travel Demand Management Strategies on Commuting Behavior," Washington, D.C.: Travel Model Improvement Program, U.S. Department of Transportation, 1994.

Cervero, R. "Mixed Land-Uses and Commuting: Evidence from the American Housing Survey." *Transportation Research A*, Vol. 30, 1996, pp. 361–377.

———. "Alternative Approaches to Modeling the Travel–Demand Impacts of Smart Growth." *Journal of the American Planning Association*, Vol. 72(3), 2006, pp. 285–295.

Cervero, R. and K. Kockelman. "Travel Demand and the 3Ds: Density, Diversity, and Design." *Transportation Research Part D*, Vol. 2, 1997, pp. 199–219.

Crane, R. "The Influence of Urban Form on Travel: An Interpretive Review." *Journal of Planning Literature*, Vol. 15, No. 1, August 2000.

Cutsinger, J. and G. Galster. "There Is No Sprawl Syndrome: A New Typology of Metropolitan Land Use Patterns." *Urban Geography*, Vol. 27, No. 3, April–May 2006, pp. 228–252.

Cutsinger, J., G. Galster, H. Wolman, R. Hanson, and D. Towns. "Verifying the Multi-Dimensional Nature of Metropolitan Land Use: Advancing the Understanding and Measurement of Sprawl." *Journal of Urban Affairs*, Vol. 27, Issue 3, 2005, pp. 235–259.

Deakin, E., G. Harvey, R. Pozdena, G. Yarema et al. *Transportation Pricing Strategies for California: An Assessment of Congestion, Emissions, Energy and Equity Impacts.* Sacramento: California Air Resources Board, 1996.

DKS Associates and University of California. *Assessment of Local Models and Tools for Analyzing Smart-Growth Strategies.* Irvine, California: University of California, 2007, www.dot.ca.gov/hq/research/researchreports/reports/2007/local_models_tools.pdf.

Environmental Protection Agency (EPA). "Project XL and Atlantic Steel—Supporting Environmental Excellence and Smart Growth," September 1999 (EPA 231-R-99-004), http://www.epa.gov/projctxl/atlantic/page1.htm

———. "Comparing Methodologies to Assess Transportation and Air Quality," August 2001a (EPA 231-R-01-001).

———. "EPA's Smart Growth INDEX In 20 Pilot Communities: Using GIS Sketch Modeling to Advance Smart Growth," August 2001b (EPA 231-R-03-001).

———. "Environmental Benefits of Brownfield Redevelopment," unpublished draft, July 2006.

Ewing, R. "Beyond Density, Mode Choice, and Single-Purpose Trips." *Transportation Quarterly*, Vol. 49, 1995, pp. 15–24.

———. "Research You Can Use: Regional Scenario Plans and Meta-Analysis." *Planning*, March 2007, p. 38.

Ewing, R., R. Brownson, and D. Berrigan. "Relationship between Urban Sprawl and Weight of U.S. Youth." *American Journal of Preventive Medicine*, Vol. 31, Issue 6, 2006, pp. 464–474.

Ewing, R. and R. Cervero. "Travel and the Built Environment." *Transportation Research Record*, Vol. 1780, 2001, pp. 87–114.

Ewing, R., P. Haliyur, and G.W. Page. "Getting Around a Traditional City, a Suburban PUD, and Everything In-Between." *Transportation Research Record*, Vol. 1466, 1994, pp. 53–62.

Ewing, R., R. Pendall, and D. Chen. *Measuring Sprawl and Its Impact.* Washington, D.C.: Smart Growth America/U.S. Environmental Protection Agency, 2002.

———. "Measuring Sprawl and Its Transportation Impacts." *Journal of the Transportation Research Board*, Vol. 1832, 2003, pp. 175–183.

Ewing, R., T. Schmid, R. Killingsworth, A. Zlot, and S. Raudenbush. "Relationship Between Urban Sprawl and Physical Activity, Obesity, and Morbidity." *American Journal of Health Promotion*, Vol. 18, No. 1, 2003, pp. 47–57.

Frank, L.D. "Land Use and Transportation Interaction: Implications on Public Health and Quality of Life." *Journal of Planning Education and Research*, Vol. 20, Issue 1, 2000, pp. 6–22.

Frank, L.D. and P. Engelke. "The Built Environment and Human Activity Patterns: Exploring the Impacts of Urban Form on Public Health." *Journal of Planning Literature*, Vol. 16, Issue 2, 2001, pp. 202–218.

———. "Multiple Impacts of the Built Environment on Public Health: Walkable Places and the Exposure to Air Pollution." *International Regional Science Review*, Vol. 28, Issue 2, 2005, pp. 193–216.

Galster, G., R. Hanson, M. Ratcliffe, H. Wolman, S. Coleman, and J. Freihage. "Wrestling Sprawl to the Ground: Defining and Measuring an Elusive Concept." *Housing Policy Debate*, Vol. 12, No. 4, 2001.

Gomez-Ibanez, A. "A Global View of Automobile Dependence." *Journal of the American Planning Association*, Vol. 57, 1991, pp. 376–379.

Gordon, P., A. Kumar, and H.W. Richardson. "Congestion, Changing Metropolitan Structure, and City Size in the United States." *International Regional Science Review*, Vol. 12, Issue 1, 1989, pp. 45–56.

Gordon, P. and H.W. Richardson. "Gasoline Consumption and Cities—A Reply." *Journal of the American Planning Association.* Vol. 55, 1989, pp. 342–346.

Gupta, S., S. Kalmanje, and K.M. Kockelman. "Road Pricing Simulations: Traffic, Land Use and Welfare Impacts for Austin, Texas." *Transportation Planning & Technology*, Vol. 29, Issue 1, 2006, pp. 1–23.

Hagler Bailly, Inc. *Transportation and Environmental Analysis of the Atlantic Steel Development Proposal.* Washington, D.C.: U.S. Environmental Protection Agency, February 1998.

Hagler Bailly, Inc. and Criterion Planners/Engineers. *The Transportation and Environmental Impacts of Infill versus Greenfield Development: A Comparative Case Study Analysis*, EPA 231-R-99-005. Washington, D.C.: U.S. Environmental Protection Agency, October 1999.

Handy, S. "Critical Assessment of the Literature on the Relationships among Transportation, Land Use, and Physical Activity," prepared for the Transportation Research Board and Institute of Medicine Committee on Physical Activity, Health, Transportation, and Land Use, Washington, D.C., January 2006, http://trb.org/ downloads/sr282papers/sr282Handy.pdf.

Heath, G.W., R.C. Brownson, J. Kruger, R. Miles, K.E. Powell, L.T. Ramsey, and the Task Force on Community Preventive Services. "The Effectiveness of Urban Design and Land Use and Transport Policies and Practices to Increase Physical Activity: A Systematic Review." *Journal of Physical Activity and Health*, Vol. 3, 2006, pp. S55–S76.

Holtzclaw, J. "Explaining Urban Density and Transit Impacts on Auto Use." San Francisco: Sierra Club, 1991.

———. "Using Residential Patterns and Transit to Decrease Auto Dependence and Costs." San Francisco: Natural Resources Defense Council, 1994.

Holtzclaw, J., R. Clear, H. Dittmar, D. Goldstein, and P. Haas. "Location Efficiency: Neighborhood and Socioeconomic Characteristics Determine Auto Ownership and Use—Studies in Chicago, Los Angeles and San Francisco." *Transportation Planning and Technology*, Vol. 25, 2002, pp. 1–27.

Hu, P.S. and T.R. Reuscher. *Summary of Travel Trends: 2001 National Household Travel Survey.* Washington, D.C.: Federal Highway Administration, 2004, http://nhts.ornl.gov/2001/pub/STT.pdf.

IBI Group, Canada Mortgage and Housing Corporation, and Natural Resources Canada. *Greenhouse Gas Emissions for Urban Travel: Tool for Evaluating Neighbourhood Sustainability*, February 2000.

Johnston, R. "The Urban Transportation Planning Process." In S. Hanson and G. Guiliano (eds.), *The Geography of Urban Transportation.* New York: Guilford Press, 2004, pp. 115–140.

———. "Review of U.S. and European Regional Modeling Studies of Policies Intended to Reduce Motorized Travel, Fuel Use, and Emissions." Victoria Transport Policy Institute, 2006, www.vtpi.org.

*Journal of the American Planning Association.* Special Issue on Health and Planning. M. Boarnet (ed.), Winter 2006.

Kahn, M.E. "The Quality of Life in Sprawled versus Compact Cities," prepared for the OECD ECMT Regional Round, Berkeley, California, March 2006, Table 137, pp.27–28.

Khattak, A.J. and D. Rodriquez. "Travel Behavior in Neo-Traditional Neighborhood Developments: A Case Study in USA." *Transportation Research Part A*, Vol. 39, 2005, pp. 481–500.

Komanoff, C. *Environmental Consequences of Road Pricing: A Scoping Paper for the Energy Foundation,* 1997, www.tstc.org/reports/ckdraft6.pdf.

Krizek, K.J. "Residential Relocation and Changes in Urban Travel: Does Neighborhood-Scale Urban Form Matter?" *Journal of the American Planning Association*, Vol. 69, Issue 3, 2003, pp. 265–281.

Leck, E. "The Impact of Urban Form on Travel Behavior: A Meta-Analysis." *Berkeley Planning Journal*, Vol. 19, 2006, pp. 37–58.

Lee, C. and A. Vernez Moudon. "Physical Activity and Environment Research in the Health Field: Implications for Urban and Transportation Planning Practice and Research." *Journal of Planning Literature*, Vol. 19, 2004, pp. 147–181.

Levinson, D. and A. Kumar. "Activity, Travel, and the Allocation of Time." *Journal of the American Planning Association*, Vol. 61, Issue 4, 1995, pp. 458–470.

Limanond, T. and D.A. Niemeier. "Effect of Land Use on Decisions of Shopping Tour Generation: A Case Study of Three Traditional Neighborhoods in WA." *Transportation*, Vol. 31, 2004, pp. 153–181.

McCann, B. and R. Ewing. "Measuring the Health Effects of Sprawl." Washington, D.C.: Smart Growth America/Robert Wood Johnson Foundation, 2003.

McGuckin, N., J.P. Zmud, and Y. Nakamoto. "Trip-Chaining Trends in the United States: Understanding Travel Behavior for Policy Making." *Transportation Research Record*, Vol. 1917, 2005, pp. 199–2004.

Moudon, A.V. et al. "Effects of Site Design on Pedestrian Travel in Mixed-Use, Medium-Density Environments." *Transportation Research Record*, Vol. 1578, 1997, pp. 48–55.

Nasser, H.E. and P. Overberg, "What You Don't Know about Sprawl: Controlling Development a Big Concern, but Analysis Has Unexpected Findings," *USA Today*, February 22, 2001.

Natural Resources Defense Council (NRDC). *Environmental Characteristics of Smart Growth Neighborhoods: An Exploratory Case Study.* Washington, D.C., October 2000, www.nrdc.org/cities/smartGrowth/char/charinx.asp.

Newman, P.W.G. "Transport Greenhouse Gases and Australian Suburbs." *Australian Planner*, Vol. 43 (2), 2006, pp. 6–7.

Newman, P.W.G. and J.R. Kenworthy. "The Transport Energy Trade-Off: Fuel-Efficient Traffic versus Fuel-Efficient Cities." *Transportation Research A*, Vol. 22A, Issue 3, 1988, pp. 163–174.

———. *Cities and Automobile Dependence: An International Sourcebook.* Aldershot, United Kingdom: Gower Publishing, 1989a.

———. "Gasoline Consumption and Cities: A Comparison of U.S. Cities with a Global Survey." *Journal of the American Planning Association*, Vol. 55A, 1989b, pp. 24–37.

———. "Urban Design to Reduce Automobile Dependence." *Opolis: An International Journal of Suburban and Metropolitan Studies,* Vol. 2, Issue 1, 2006, pp. 35–52.

———. "Greening Urban Transportation." In M. O'Meara (ed.), *State of the World 2007: Our Urban Future*, Washington, D.C.: Norton Publishers, 2007.

Noland, R.B and J.V. Thomas. "Multivariate Analysis of Trip-Chaining Behavior." Transportation Research Board, 85th Annual Meeting CD, 2006.

Oster, C.V. "Household Tripmaking to Multiple Destinations: The Overlooked Urban Travel Pattern." *Traffic Quarterly*, Vol. 32, 1978, pp. 511–529.

Owen, N., N. Humpel, E. Leslie, A. Bauman, and J.F. Sallis. "Understanding Environmental Influences on Walking; Review and Research Agenda." *American Journal of Preventive Medicine*, Volume 27, Issue 1, 2004, pp. 67–76.

Raudenbush, S.W. and A.S. Byrk. *Hierarchical Linear Models: Applications and Data Analysis Methods* (second edition). Thousand Oaks, California: Sage Publications, 2002.

Sacramento Area Council of Governments (SACOG) and Valley Vision. Sacramento Region Blueprint, undated, www.sacregionblueprint.org/sacregionblueprint/home.cfm.

Sacramento Area Council of Governments (SACOG), Preferred Blueprint Alternative, Special Report, January 2005.

Saelens, B.E., J.F. Sallis, and L.D. Frank. "Environmental Correlates of Walking and Cycling: Findings from the Transportation, Urban Design, and Planning Literatures." *Annals of Behavioral Medicine*, Vol. 25, Issue 2, 2003, pp. 80–91.

Sarzynski, A., H.L. Wolman, G. Galster, and R. Hanson. "Testing the Conventional Wisdom About Land Use and Traffic Congestion: The More We Sprawl, the Less We Move?" *Urban Studies*, Vol. 43, Issue 3, 2006, pp. 601–626.

Schrank, D. and T. Lomax. *The 2005 Urban Mobility Report.* College Station: Texas Transportation Institute, 2005, http://mobility.tamu.edu/ums/.

U.S. Conference of Mayors. Clean Air/Brownfields Report. Washington, D.C., December 2001.

Walters, J., R. Ewing, and E. Allen. "Adjusting Computer Modeling Tools to Capture Effects of Smart Growth." *Transportation Research Record*, Vol. 1722, 2000, pp. 17–26.

## Chapter 4: Environmental Determinism versus Self Selection

Belden Russonello & Stewart. *Americans' Attitudes Toward Walking and Creating Better Walking Communities.* Washington, D.C.: Surface Transportation Policy Project, April 2003, www.transact.org/library/reports_pdfs/pedpoll.pdf.

Cao, X., P. Mokhtarian, and S. Handy. *Examining the Impacts of Residential Self-Selection on Travel Behavior: Methodologies and Empirical Findings.* Research Report UCD-ITS-RR-06-18, Institute of Transportation Studies, University of California, Davis, December 2006, http://pubs.its.ucdavis.edu/publication_detail.php?id=1057.

Center for Transit-Oriented Development. *Hidden in Plain Sight: Capturing the Demand for Housing Near Transit.* Washington, D.C., September 2004.

Cervero, R. and M. Duncan. *Residential Self Selection and Rail Commuting: A Nested Logit Analysis.* UCTC Working Paper 604, Berkeley, California: University of California Transportation Center, 2003, http://www.uctc.net/papers/604.pdf.

Dill, J. "Travel Behavior and Attitudes: New Urbanist vs. Traditional Suburban Neighborhoods," presented at the 2004 Annual Meeting of the Transportation Research Board, Washington, D.C.

Frank, L., B. Saelens, K.E. Powell, and J.E. Chapman. "Stepping Towards Causation: Do Built Environments or Neighborhood and Travel Preferences Explain Physical Activity, Driving, and Obesity?" *Social Science & Medicine*, forthcoming.

Levine J., A.Inam, G. Tong. "A Choice-Based Rationale for Land Use and Transportation Alternatives—Evidence from Boston and Atlanta." *Journal of Planning Education and Research*, Vol. 24, No. 3, 2005, pp. 317–330.

Levine, J. and L.D. Frank. "Transportation and Land-Use Preferences and Residents' Neighborhood Choices: The Sufficiency of Compact Development in the Atlanta Region." *Transportation*, Vol. 34, 2007, pp. 255–274.

Lund, H. "Reasons for Living in a Transit-Oriented Development, and Associated Transit Use." *Journal of the American Planning Association*, Vol. 72, No. 3, 2006, pp. 357–366.

Lund, H., R. Willson, and R. Cervero. "A Re-Evaluation of Travel Behavior in California TODs." *Journal of Architectural and Planning Research*, forthcoming.

Mokhtarian, P. and X. Cao. "Examining the Impacts of Residential Self-Selection on Travel Behavior: A Focus on Methodologies." *Transportation Research Part B*, forthcoming.

Myers, D. and E. Gearin. "Current Preferences and Future Demand for Denser Residential Environments." *Housing Policy Debate*, Vol. 12, Issue 4, 2001, pp. 633–659.

Nelson, A.C. "Leadership in a New Era." *Journal of the American Planning Association*, Vol. 72, No. 4, 2006, pp. 393–407.

Rose, M. "Neighborhood Design & Mode Choice," Portland State University, Field Area Paper, Masters of Urban and Regional Planning, 2004.

Transportation Research Board/Institute of Medicine. *Does the Built Environment Influence Physical Activity? Examining the Evidence.* Washington, D.C.: National Academy of Sciences, 2005.

## Chapter 5: Induced Travel and Induced Development

Bhatta, S.D. and M.P. Drennan. "The Economic Benefits of Public Investment in Transportation: A Review of Recent Literature." *Journal of Planning Education and Research*, Vol. 22, Issue 3, 2003, pp. 288–296.

Boarnet, M.G. "Highways and Economic Productivity: Interpreting Recent Evidence." *Journal of Planning Literature*, Vol. 11, Issue 4, 1997, pp. 476–486.

Boarnet, M.G. and A. Haughwout. "Do Highways Matter? Evidence and Policy Implications of Highways' Influence on Metropolitan Development." Washington, D.C.: Brookings Institution, 2000.

Cervero, R. "Induced Travel Demand: Research Design, Empirical Evidence, and Normative Policies." *Journal of Planning Literature*, Vol. 17, Issue 1, 2002, pp. 3–20.

Cervero, R. and J. Landis. "The Transportation-Land Use Connection Still Matters." *Access*, Vol. 7, 1995, pp. 2–10.

Czamanski, S. "Effects of Public Investments on Urban Land Values." *Journal of the American Institute of Planners*, Vol. 32, 1966, pp. 204–217.

Downs, A. "The Law of Peak-Hour Express Way Congestion." *Traffic Quarterly*, Vol. 16, July 1962, pp. 393–409.

Downs, A. "Traffic: Why It's Getting Worse, What Government Can Do." Policy Brief #128, Washington, D.C.: Brookings Institution, 2004, www.brookings.edu/printme.wbs?page=/comm/policybriefs/pb128.htm.

Ewing, R. "Induced Transportation Operating Costs." In R. Burchell et al., *Calculating the Transportation Cost Impacts of New Development: Literature Review Related to Procedures.* National Cooperative Highway Research Program Project 08-59, August 17, 2007 draft, pp. 83–104.

Giuliano, G. "The Weakening Transportation-Land Use Connection." *Access*, Vol. 6, 1995, pp. 3–11.

Hansen, M. and Y. Huang. "Road Supply and Traffic in California Urban Areas." *Transportation Research A*, Vol. 31, Issue 3, 1997, pp. 205–218.

Huang, W. "The Effects of Transportation Infrastructure on Nearby Property Values: A Review of the Literature." Working Paper #620, Berkeley, California: Institute of Urban and Regional Development, University of California, 1994.

Mohring, H. "Land Values and the Measurement of Highway Benefits." *Journal of Political Economy*, Vol. 79, 1961, pp. 236–249.

National Capital Region Transportation Planning Board/Metropolitan Washington Council of Governments (NCRTPB/MWCOG). "Induced Travel: Definition, Forecasting Process, and a Case Study in the Metropolitan Washington Region." Washington, D.C., Sept. 19, 2001.

Ryan, S. "Property Values and Transportation Facilities: Finding the Transportation-Land Use Connection." *Journal of Planning Literature*, Vol. 13, Issue 4, 1999, pp. 412–427.

*Washington Post.* "Widen the Roads, Drivers Will Come—MD's I-270 Offers a Lesson," Jan. 4, 1999.

## Chapter 6: The Residential Sector

Bento, A.M., M.L. Cropper, A. Mobarak, and K. Vinha. *The Impact of Urban Spatial Structure on Travel Demand in the United States.* Washington, D.C.: World Bank, 2003.

Burchell, R.W. et al. *The Costs of Sprawl—Revisited.* Washington, D.C.: Transportation Research Board, 1998.

Environmental Protection Agency (EPA). *Characteristics and Performance of Regional Transportation Systems.* Washington, D.C., 2003.

Energy Information Administration (EIA). "Emissions of Greenhouse Gases in the United States 2003." Washington, D.C., 2004.

Ewing, R. "Characteristics, Causes, and Effects of Sprawl: A Literature Review." *Environmental and Urban Issues*, Vol. 21, Issue 2, 1994, pp. 1–15.

Frank, L.D. and P. Engelke. "Multiple Impacts of the Built Environment on Public Health: Walkable Places and the Exposure to Air Pollution." *International Regional Science Review*, Vol. 28, Issue 2, 2005, pp. 193–216.

Frank, L.D., J.F. Sallis, T.L. Conway, J.E. Chapman, B.E. Saelens, and W. Bachman. "Many Pathways from Land Use to Health." *Journal of the American Planning Association*, Vol. 72, Issue 1, 2006, pp. 75–87.

Kessler, J. and W. Schroeer. "Meeting Mobility and Air Quality Goals: Strategies that Work." *Transportation,* Vol. 22, Issue 3, 1995, pp. 241–272.

Kunkle, R. et al. "New Imagery and Directions for Residential Sector Energy Policies." American Council for an Energy-Efficient Economy, ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California, 2004.

Lebot, B. et al. "Consumption versus Efficiency: Have We Designed the Right Policies and Programs?" American Council for an Energy-Efficient Economy, ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California, 2004.

Rong, F. and R. Ewing. *Impact of Urban Form on U. S. Residential Energy Use*. Working Paper, National Center for Smart Growth, University of Maryland, College Park, 2007.

Siderius, H.P. "The End of Energy Efficiency Improvement = The Start of Energy Savings?!" American Council for an Energy-Efficient Economy, ACEEE Summer Study on Energy Efficiency in Buildings, Pacific Grove, California, 2004.

## Chapter 7: Policy and Program Alternatives

Bernstein, Scott, David Burwell, Steve Winklemann; *Climate Matters: the Case for Addressing Greenhouse Gas Reduction in Federal Transportation Policy*; Funders Network for Smart Growth & Livable Communities, 2003 at http://www.fundersnetwork.org/info-url_nocat2778/info-url_nocat_show.htm?doc_id=148724.

Bernstein, Scott, Bruce Katz, and Robert Puentes. *TEA21 Reauthorization: Getting Transportation Right for Metropolitan America.* Brookings Institution. 2003; this paper is being

updated with input from a July 2007 retreat and will be release by Brookings this fall, contact rpuentes@brookings.edu.

Congressional Budget Office, *Trends in Public Spending on Transportation and Water Infrastructure, 1956 to 2004*. August 2007. http://www.cbo.gov/ftpdocs/85xx/doc8517/08-08-Infrastructure.pdf

Center for Neighborhood Technology, resources and publications available at www.cnt.org/resources.

Center for Strategic and International Studies, *Guiding Principles for Strengthening America's Infrastructure*. Commission on Public Infrastructure, March 27, 2006.

Center for Transit Oriented Development, resources and publications available at www.reconnectingamerica.org.

Feigon, Sharon, Sarah Campbell et. al., Travel Matters: Combating Climate Change with Sustainable Surface Transportation, TCRP Report 93, National Academy of Sciences 2003 at http://www.trb.org/news/blurb_detail.asp?id=4555, also www.travelmatters.org .

Holtzclaw, John, Robert Clear, Hank Dittmar, David Goldstein, and Peter Haas. "Location Efficiency: Neighborhoods and Socioeconomic Characteristics Determine Automobile Use." ***Transportation Planning and Technology***, 2002, Volume 25, 1-27.

Mcgraw, J., N. Friedman, C. Bendowitz, S. Bernstein, Low Carbon Mobility, Ch. 8 in Presidential Climate Action Project, forthcoming, 2007, at www.climateactionproject.org.

Surface Transportation Policy Partnership, resources and publications available at www.transact.org.

ULI–the Urban Land Institute and PricewaterhouseCoopers LLP. *Emerging Trends in Real Estate 2007.* Washington, D.C.: ULI–the Urban Institute, 2007.

## Related ULI Publications


Beyard, Michael D. et al. *Ten Principles for Developing Successful Town Centers*. Washington, D.C.: ULI–the Urban Institute, 2007.

Beyard, Michael D. et al. *Ten Principles for Rebuilding Neighborhood Retail*. Washington, D.C.: ULI–the Urban Land Institute, 2003.

Beyard, Michael D. and Michael Pawlukiewicz. *Ten Principles for Reinventing America's Suburban Strips*. Washington, D.C.: ULI–the Urban Land Institute, 2001.

Bohl, Charles. *Place Making and Town Center Development*. Washington, D.C.: ULI–the Urban Land Institute, 2003.

Booth, A. Geoffrey. *Transforming Suburban Business Districts*. Washington, D.C.: ULI–the Urban Land Institute, 2001.

Booth, Geoffrey et al. *Ten Principles for Reinventing Suburban Business Districts*. Washington, D.C.: ULI–the Urban Land Institute, 2002.

Dunphy, Robert T. *Developing Around Transit: Strategies and Solutions That Work*. Washington, D.C.: ULI–the Urban Land Institute, 2004.

Gause, Jo Allen. *Great Planned Communities*. Washington, DC: ULI–the Urban Land Institute, 2002.

Gause, Jo Allen and Richard Franko. *Developing Sustainable Planned Communities*. Washington, D.C.: ULI–the Urban Land Institute, 2007.

Gupta, Prema Katari. *Compact Development: Changing the Rules to Make it Happen*. Washington, D.C.: ULI–the Urban Land Institute, 2007.

———. *Creating Great Town Centers and Urban Villages*. Washington, D.C.: ULI–the Urban Land Institute, forthcoming (2008).

Haughey, Richard. *Urban Infill Housing: Myth and Fact*. Washington, D.C.: ULI–the Urban Land Institute, 2001.

———. *Higher-Density Development: Myth and Fact*. Washington, D.C.: ULI–the Urban Land Institute, 2005.

———. *Getting Density Right: Tools for Creating Vibrant Compact Development*. ULI–the Urban Land Institute, Forthcoming (2008).

Heid, James M. *Greenfield Development Without Sprawl: The Role of Planned Communities.* Washington, D.C.: ULI–the Urban Land Institute, 2004.

Levitt, Rachelle L. and Dean Schwanke. *Mixed-Use Development Handbook.* Washington, D.C.: ULI–the Urban Land Institute, 2003.

Pawlukiewicz, Michael. *Ten Principles for Smart Growth on the Suburban Fringe.* ULI–the Urban Land Institute, 2003.

Peiser, Richard B. and Adrienne Schmitz. *Regenerating Older Suburbs.* Washington, D.C.: ULI–the Urban Land Institute, 2007.

Porter, Douglas R. *Making Smart Growth Work.* Washington, D.C.: ULI–the Urban Land Institute, 2003.

———. *Smart Growth Transportation for Suburban Greenfields.* Washington, D.C.: ULI–Urban Land Institute, 2003.

Schmitz, Adrienne. *The New Shape of Suburbia: Trends in Residential Development.* Washington, D.C.: ULI–the Urban Land Institute, 2003.

Schmitz, Adrienne and Jason Scully. *Creating Walkable Places: Compact Mixed-Use Solutions.* Washington, D.C.: ULI–the Urban Land Institute, 2006.

Suchman, Diane R. *Developing Successful Infill Housing.* Washington, D.C.: ULI–the Urban Land Institute, 2002.

Attachment 28

International Expert Meeting on Urban Flood Management
20-21 November 2003, World Trade Center Rotterdam, The Netherlands

# California Climate Change, Hydrologic Response, and Flood Forecasting

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## Introduction

California has ecological, cultural, and geographical diversity with 10 natural bioregions (Northern Coastal, Central Coastal, Southern Coastal, Great Central Valley, Cascade Mountains, Sierra Nevada Mountains, East of Sierra Nevada, Mojave Desert, and Sonoran Desert), and several urban centers. Its population exceeds 33 million, with the largest concentrations in the Los Angeles Basin, San Francisco Bay Area, and within the Central Valley. It has an area of approximately 420,000 km$^2$, with over 2000 km of coastline, and 3000 km$^2$ of lakes, bays, and deltas. Areas within the San Francisco Bay Delta are below sea level and have levees, retaining walls, and drainage ponds, which along with the California coastal areas, are vulnerable to storm-generated tidal surges, flooding, erosion, and loss of property.

California has experienced long dry and unusually wet periods. Oxygen-18 isotope analyses (Ingram et al. 1996) of San Francisco Bay sediments dating back to about 1200 A.D have indicated changes in salinity, which are indicators of fresh water inflow to the San Francisco Bay. Periods of very high fresh water inflow to the San Francisco Bay (i.e. increased precipitation and low salinity) alternate with periods of low fresh water inflow (i.e. decreased precipitation and high salinity). During the 1500s, there appears to have been a drought that lasted more than 50 years (Fig. 1). Since the beginning of the 1900s, California has been wetter than average, and large engineering projects for water storage and conveyance of Sierra Nevada snowmelt runoff have contributed to the economic growth of California. The sustainability of this region is closely aligned with the availability of fresh water, the storage of this water during dry periods, and the reduction or adaptation to major floods that can potentially damage vital infrastructure.

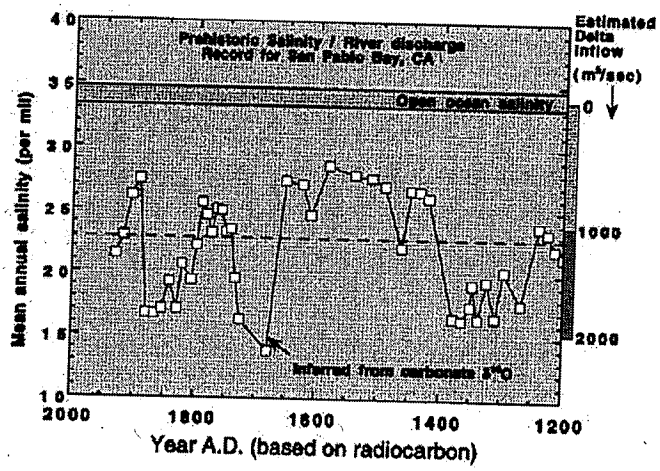



Fig. 1. Oxygen-18 isotope dating of sediments indicates pre-historic periods of high salinity and low inflow (low precipitation), and periods of low salinity and high inflow (high precipitation). The red side-bar represents the estimated fresh water inflow corresponding to the salinity concentration (Ingram et al. 1996).

California has a Mediterranean climate and receives precipitation from November to April, with May through October being dry month. Precipitation is from the Pacific Ocean and involves large-scale atmospheric circulations that are influenced by Pacific Ocean sea surface temperatures (SSTs). The SST patterns affect low frequency climate oscillations that impact precipitation rates in regions around the world through natural teleconnected climate variations. For California, the two most significant are the El Nino Southern Oscillation (ENSO) and the Pacific multi-Decadal Oscillation (PDO). ENSO has a 3-5 year cycle, responds to changes in the western equatorial Pacific Ocean SSTs, and is termed El Nino for its positive phase, and La Nina for its negative phase. The PDO responds to SST patterns in the northern, equatorial, and southern Pacific Ocean, has an approximately 30 year cycle, and is weaker than ENSO. Major El Nino phase events are shown in Fig. 2 and the global precipitation impacts due to the very large 1982-1983 El Nino are shown Fig. 3.

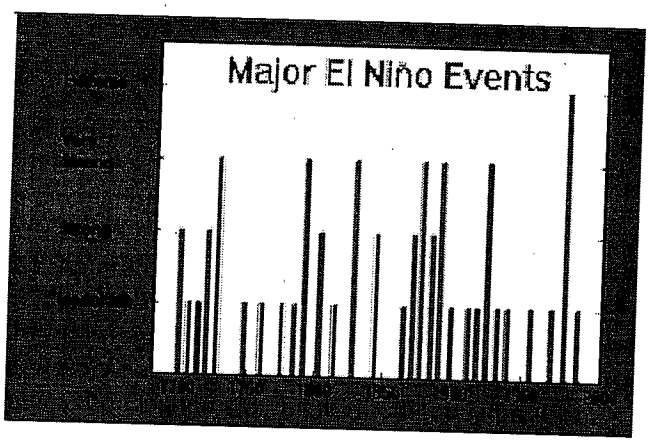



Fig. 2. Major El Nino events since 1700. The 1982-1983 event was the largest on record.

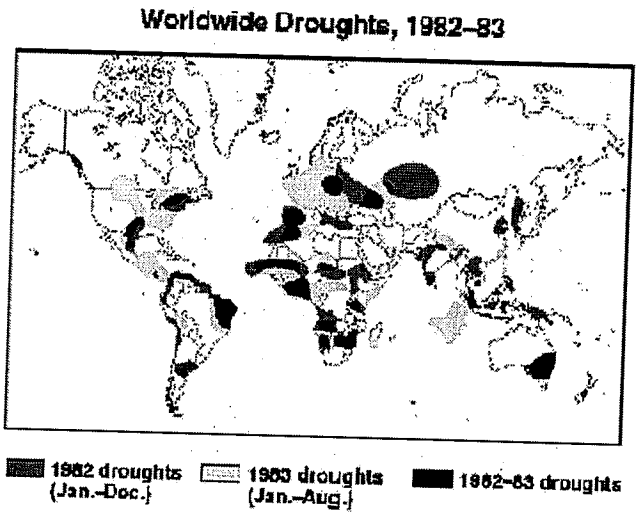



Fig. 3. During the 1982-1983 El Nino, teleconnected patterns caused global impacts, most importantly droughts and floods.

During the last 50 years, there has been an observed global warming of the lower atmosphere at rates greater than direct observations over the previous 150 years and greater than proxy studies that date back 1000 years (Fig. 4). As much as 30 percent of this recent warming can be attributed to natural climate variability, including ENSO, PDO, and other phenomena. However, studies have provided strong evidence of climate change due to the emission of carbon dioxide ($CO_2$) and other anthropogenic green house gas (GHG) emissions. Since the late 1950s, observations have indicated that the global temperature of the lower atmosphere (troposphere) has increased on average 0.1°C per decade, with the 1990s the warmest decade of the century. Global input of $CO_2$ to the atmosphere from fossil fuel combustion has exponentially increased since the beginning of the industrial revolution (i.e. 1860) at about 4% per year. Atmospheric $CO_2$ measurements (Keeling et al. 1989) from Mauna Loa, Hawaii beginning in the late 1950s show increasing atmospheric $CO_2$ concentrations from near 280 ppm during the late 1950s to concentrations greater than 360 ppm in the 1990s (Fig. 5). Ice core measurements from Vostok, Antarctica indicate that the atmospheric $CO_2$ concentration was less than 280 ppm for the last 100,000 years (Barnola et al. 1987). It is well understood that $CO_2$ and other anthropogenic emissions (e.g. methane, nitrous oxide, halocarbons) act as heat trapping GHGs, that radiatively force the global climate and increase tropospheric temperature. This increase in atmospheric $CO_2$ concentration and temperature appears to be causing a range of impacts, some of which may have adverse consequences.

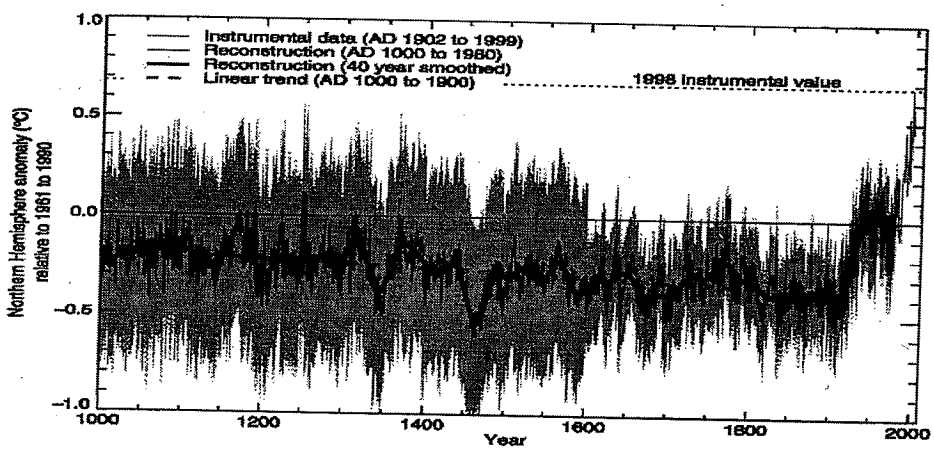
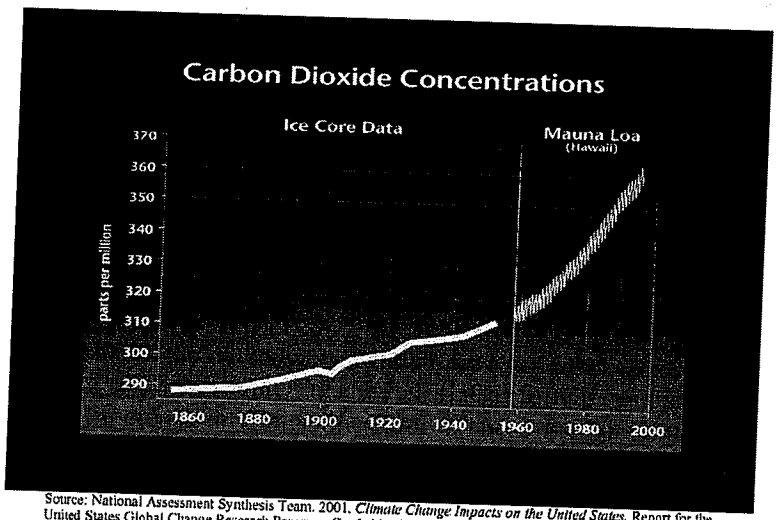



Fig. 4. The observed temperature record from 1860 to present is shown in red, the reconstructed paleo-temperature record for the period 1000 to 1980 AD is shown in blue, with a 40 year smoothed version of the paleo-record in black. The linear trend (red dashed) decreases until about 1860, when historically high rates of temperature increase are observed.

In response to this warming and the potential impacts, the Intergovernmental Panel on Climate Change (IPCC) was established in 1988 and the First Assessment Report released in 1990 provided a discussion of these concerns and provided global and regional climate model projections, framed with uncertainties (IPCC 1990). In 1995, the IPCC Second Assessment Report (IPCC 1995) stated that the balance of evidence suggested a discernable human influence on global climate. The Third Assessment Report (IPCC 2001) has stated that there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities, and warming will continue throughout the 21st century.

The IPCC (2001) ranked the confidence limits of major impacts to water resources due to observed and projected climate change as very high (0.95-1.00), high (0.67-0.95), medium (0.33-0.67), low (0.05-0.33), and very low (0.00-0.05). There is high confidence that the timing and amount of runoff is changing, and very high confidence that watersheds with substantial snowpack will experience major changes as temperature continues to rise. The impacts of this trend are a decrease in available water resources in California, primarily during the summer months, and a potential increase in wintertime floods. There is high confidence that California's Sierra Nevada will experience a continued trend of decreased snow accumulation and earlier snowmelt (e.g. Lettenmaier and Gan 1990; Jeton et al. 1996; Miller et al. 1999; Wilby and Dettinger 2000; Knowles and Cayan 2002; Miller et al. 2003).




Source: National Assessment Synthesis Team. 2001. *Climate Change Impacts on the United States*. Report for the United States Global Change Research Program. Cambridge Univ. Press. http://prod.gcrio.org/nationalassessment/

Fig. 5. The observed $CO_2$ concentration at Mauna Loa for 1959 to 1995 correlates well with the observed temperature increase shown in Fig. 4.

Precipitation change is very location-dependent and at present there is low confidence on changes in frequency, intensity, and persistence. There is medium confidence that there will be increased flooding in regions that experience large increases in precipitation. The IPCC (2001) suggests that flooding may become a major problem, raising concerns about property damage and levee failure. There is high confidence that increased temperature will cause sea level rise through thermal expansion and increased freshwater input (snow melt runoff, glacier calving). There is high confidence that this will impact groundwater aquifers, surface freshwater systems, and urban areas in The Netherlands, the San Francisco Bay-Delta, and other low lying regions. Sea level rise will cause an increase in erosion and storm surges increasing the extent of damage to coastal areas, bays, levees, and water conveyance structures.

## Modeling Climate Change and Hydrology

Atmospheric-Ocean General Circulation Models (AOGCMs) represent a coarse spatial approximation of the global climate system and its response to changes in atmospheric composition. Climate projections are initialized by output from carbon cycle model projections indicating future $CO_2$ concentrations of 250 to 970 ppm representing GHG concentrations of 90 to 250% of the pre-industrial 280 ppm. This range brackets projected *Business as Usual* scenarios and significant GHG reduction scenarios. Aerosols such as sulphates and black carbon reflect solar radiation in the troposphere causing a cooling effect. Naturally occurring aerosols such as

volcanic emissions also play into this uncertainty. Since the 1990s, these aerosols have begun to be added as part of emission scenarios models along with $CO_2$ concentrations.

The IPCC AOGCM projections of 21st century climate, with a transient increase in greenhouse gas emissions, suggest that the global mean near-surface air temperature will increase by 1.4 to 5.8 °C, with a 95% probability interval of 1.7 to 4.9 °C by 2100 (Wigley and Raper 2001). The potential for impacts on water resources due to global warming requires a downscaled analysis of local watershed hydrology. To quantify the uncertainty in streamflow, upper and lower temperature and precipitation projections and specified incremental temperature and precipitation changes are used as input forcing to hydrologic models.

Miller et al. (2003) performed an analysis of California hydrologic response to 21st century future climate temperature and precipitation based on two AOGCM projections representing the spread of possible outcomes. The models used are the Hadley Centre HadCM2, a warm and wet projection, and the National Center for Atmospheric Research PCM, a cool and dry projection, relative to the mean of the IPCC AOGCM projections (Fig. 6). Climate change *perturbations* of the projected watershed mean-area temperature and precipitation were derived from the temperature difference and precipitation ratio between the projected climatology and the simulated present day baseline climate (1961 to 1990).

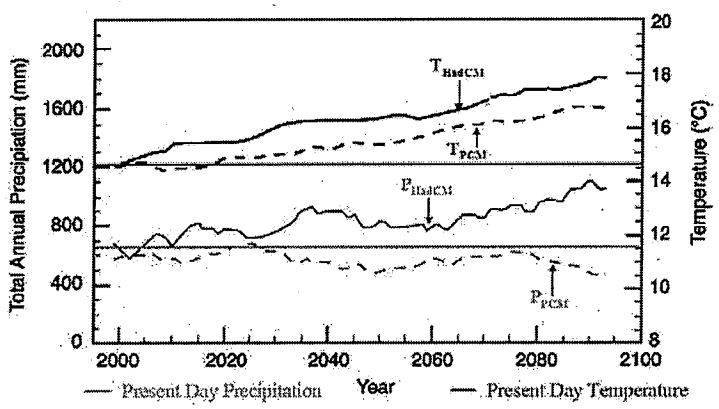



Fig. 6. The California area-averaged temperature for HadCM2 and PCM show an increase from present day (red) of approximately 4.5°C and 2.1°C, respectively, by 2100. While the HadCM2 shows a precipitation increase of approximately 1.9% and the PCM decreases by 0.85% from the present day precipitation (green).

## Hydrologic Response to Climate Change

The hydrologic response was investigated using the U.S. National Weather Service Sacramento Soil Moisture Accounting Model and Anderson Snow Model (Burnash et al. 1973) for a set of representative study watersheds (Smith River, Sacramento River, Feather River, American River, Merced River, Kings River) forced by precipitation and temperature perturbations. These watersheds (Fig. 7) were selected to evaluate the shifts in timing and magnitude for runoff in the Cascade Mountains, Sierra Nevada Mountains, and Northern Coastal mountains, as 80% of California's fresh water comes from these regions. Comparisons were made between present-day (1961-1990) hydrology and the hydrologic response to the relatively warm, wet projection and the cool, dry projection. Changes in the rain-to-snow ratio, streamflow, and the range in daily high streamflow return periods (i.e. change in probability of floods) were determined. The

following discussion is focused on a subset of these watersheds; the Sacramento, the American, and the Merced.

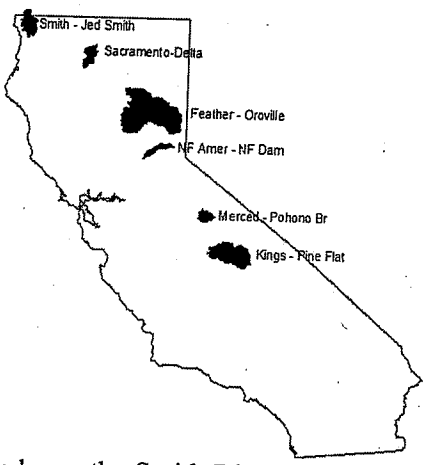



Fig. 7. California study watersheds are the Smith River, Sacramento River, Feather River, North Fork American River, Merced River, and the Kings River. These were chosen to examine the runoff response for major California fresh water sources via similarity. The discussion focuses primarily on the Sacramento, American, and Merced Rivers.

The resulting HadCM2-forced peak flow increases for the Sacramento, American and Merced during 2010 to 2039. During 2050 to 2079 and the 2080 to 2099, the peak flow magnitude continues to increase, with the greatest increase at the American River (Fig. 8, left column).

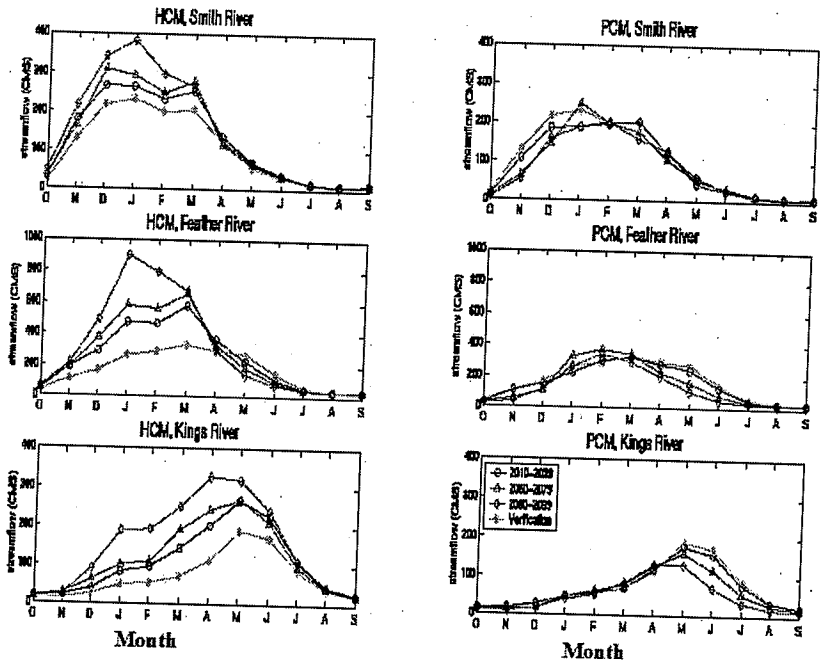



Fig. 8. Streamflow monthly climatologies based on HadCM2 (left column) and PCM (right column), for the Sacramento River, American River, and Merced River, for present day (light blue, validation), 2010-2039 (dark blue, circle), 2050-2079 (green, triangle), and 2079-2099 (red, diamond).

The peak flow timing during the 2080 to 2099 period for the American is a month earlier, occurring in February, while the Sacramento (rainfall-dominant watershed) timing remains relatively unchanged. The higher elevation Merced peak flow occurs one month later than the historical, and it also shows a secondary peak flow during December. This secondary high flow is due to increased early season snowmelt and higher snowline due to the increased temperature. The relatively cool, dry PCM-forced streamflow (right column figures) slightly decreases in total volume and significantly decreases during the March to July melt season. Peak flow remains close to the historical for the Sacramento and American for all projected periods, but the Merced shows an increase during the 2010 to 2039 period, and decreases during 2050 to 2079 and 2080 to 2099. For these projections, the American shows an earlier peak flow of one month, while the peak flow for the other two watersheds shown here remains consistent with the historical peak flow timing. Under the scenarios studied, peak streamflow in the snowmelt runoff watersheds occurs earlier and with increased magnitude and decreased summer season flow.

From a water resources perspective, the most significant finding common to both the HadCM2 and the PCM is a 50 percent decrease in total snow for California by 2100 (Fig.9). The one exception is the very high elevation Merced, which is sufficiently cold that it remains below freezing during most of the snow accumulation season. Such reductions in available fresh water will impact agricultural and urban water use. April 1st is the time when the California Department of Water Resources determines the amount of water available for the dry season.

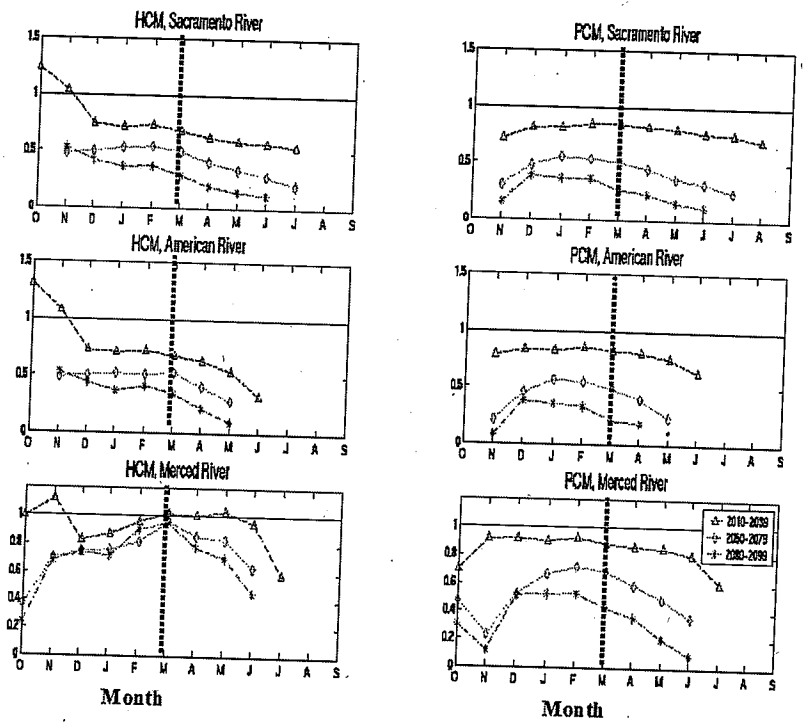



Fig. 9 The ratio of projected to present day total snow for each month based on the HadCM2 (left column) and the PCM (right column) for the Sacramento River, American River, and Merced River, for present day (light blue, validation), 2010-2039 (dark blue, circle), 2050-2079 (green, triangle), and 2079-2099 (red, diamond). The vertical dashed line represents the end of season snow amount.

Changes in the snowmelt timing coupled with increased winter-time warm precipitation (rain) suggest an increased likelihood of high streamflow days that may result in floods. To evaluate likelihoods of future flooding, 30 year high flow days were calculated and ranked for both the HadCM2 and PCM, as well as for the present day period. Fig. 10 indicates that for both the relatively warm, wet HadCM2 and cool, dry PCM, there is a significant increase in the likelihood of high flow days. For each curve shown in Fig. 10, the median of the annual maximum daily flow (50%) increases with increasing temperature. The 5% exceedance high flow (the rightmost symbols in each plot) for the projected climates exceeds current conditions, implying an increased likelihood of high flow days (i.e. floods).

## Flood Modeling

The ability to forecast high flows sufficiently far in advance under present and future climate conditions can reduce the loss of property and life. One of the first successful 48-hour advance numerical weather and streamflow forecasts was performed in January 1995 (Miller and Kim 1996a) along the Russian River in Northern Coastal California (Fig. 11). During the first week of January 1995, there were three storm systems that made landfall in the Northern Coastal region closely spaced in time. After the second storm, the ground became saturated and forecasts indicated that flooding (500 CMS) would occur 42 hours after the forecast was made. This simulation was based on a three-step procedure. Our modeling system (Miller and Kim, 1997) automatically obtained, via file transfer protocol (FTP), a global forecast from the U.S. National Weather Service. The global forecast provided our regional scale numerical weather prediction model with the initial and lateral boundary conditions needed to generate a fine-scale forecast, which in turn provided input to our coupled hydrologic model.

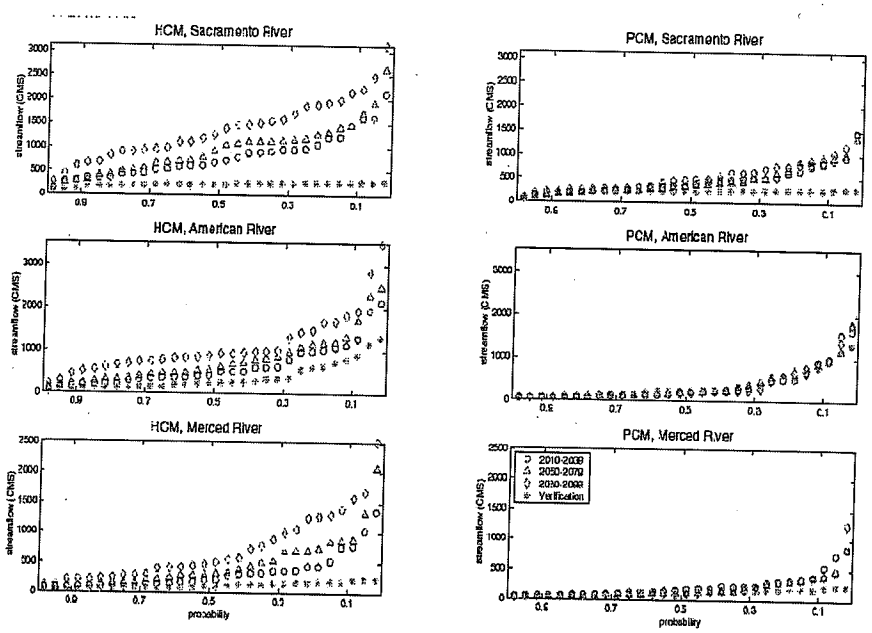



Fig. 10. Daily streamflow excedance probability based on the HadCM2 (left column) and the PCM (right column) for the Sacramento River, American River, and Merced River, for present day (light blue, validation), 2010-2039 (dark blue, circle), 2050-2079 (green, triangle), and 2079-2099 (red, diamond).

This initial work has since advanced with ensemble streamflow simulations and data assimilation. The U.S. National Weather Service-River Forecast Center has developed flash flood modeling techniques with increased forecast skill. There have been successful 72-hour streamflow forecasts when the weather system has good predictability. Now-casting has also emerged as an accurate approach for evaluating weather systems at very short time intervals based on weather radar and remote sensed data.

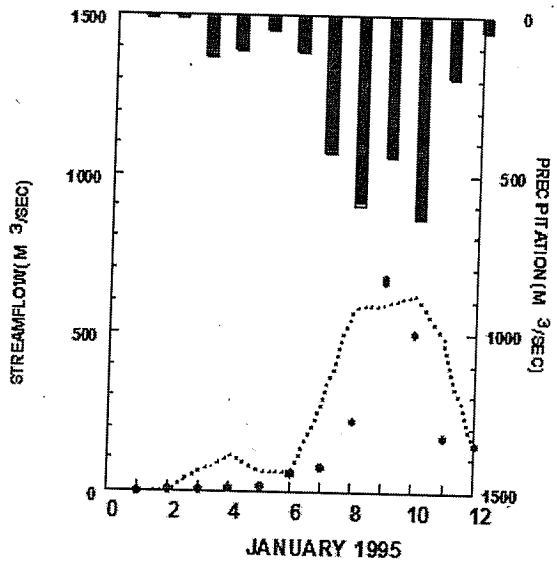



Fig. 9. One of the first 48-hour numerical weather-streamflow predictions was made for the first 12 days of January 1995. The green dashed line is the streamflow forecast, the red dots are stream gauge observations, and the blue bars are the precipitation forecast (Miller and Kim 1996).

During the last five years, the U.S. National Weather Service has been implementing the Advanced Hydrologic Prediction Services (AHPS). AHPS is a federally funded modernization initiative that allows for an incremental introduction of new products and services across the U.S.. The AHPS provide new forecast products depicting the magnitude and uncertainty of occurrence for hydrologic events from hours to days to weeks. The AHPS leverages data and systems from the U.S. National Weather Service and collaborators, including Lawrence Berkeley National Laboratory. It consists of radar data, river gage data, weather observations, snow cover/melt data, precipitation forecasts, climate predictions, reservoir releases, and satellite data.

## Summary and Conclusions

There is strong evidence that the lower atmosphere has been warming at an unprecedented rate during the last 50 years, and it is expected to further increase at least for the next 100 years. Warmer air mass implies a higher capacity to hold water vapor and an increased likelihood of an acceleration of the global water cycle. This acceleration is not validated and considerable new research has gone into understanding aspects of the water cycle (e.g. Miller et al. 2003). Several significant findings on the hydrologic response to climate change can be reported. It is well understood that the observed and expected warming is related to sea level rise. In a recent seminar at Lawrence Berkeley National Laboratory, James Hansen (Director of the Institute for

Space Studies, National Aeronautics and Space Administration) stressed that a 1.25 $Wm^{-2}$ increase in radiative forcing will lead to an increase in the near surface air temperature by 1°C. This small increase in temperature from 2000 levels is enough to cause very significant impacts to coasts. Maury Roos (Chief Hydrologist, California Department of Water Resources) has shown that a 0.3 m rise in sea level shifts the San Francisco Bay 100-year storm surge flood event to a 10-year event. Related coastal protection costs for California based on sea level rise are shown in Fig. 13 (Wilkinson et al. 2002).

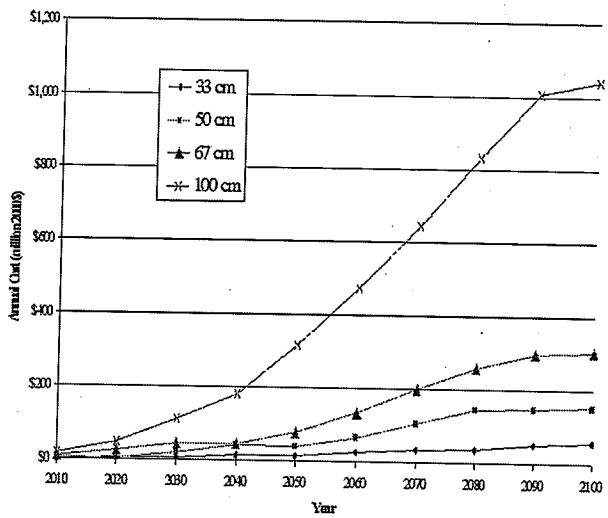



Fig. 13. California costs for coastal protection for sea level rise of 33cm, 50cm, 67cm, and 100cm.

In addition to rising sea level, snowmelt-related streamflow represents a particular problem in California. Model studies have indicated that there will be approximately a 50% decrease in snow pack by 2100. This potential deficit must be fully recognized and plans need to be put in place well in advance. In addition, the warmer atmosphere can hold more water vapor and result in more intense warm winter-time precipitation events that result in flooding. During anticipated high flow, reservoirs need to release water to maintain their structural integrity. California is at risk of water shortages, floods, and related ecosystem stresses.

More research needs to be done to further improve our ability to forecast weather events at longer time scales. Seasonal predictions have been statistical and only recently have studies begun to use ensemble simulations and historical observations to constrain such predictions. Understanding the mechanisms of large-scale atmospheric dynamics and its local impacts remain topics of intensive research.

The ability to predict extreme events and provide policy makers with this information, along with climate change and hydrologic response information, will help to guide planning to form a more resilient infrastructure in the future.

**Acknowledgements:** Support for this manuscript provided by the US Department of Energy Office of Science, Office of Biological and Environmental Research under contract DE-AC03-76F00098. Climate change and hydrologic response research was supported by NASA Grant NS-2791 and California Energy Commission. The early flood forecasting model development and

simulations were supported through a US DOE Laboratory Directed Research and Development Grant. This manuscript is Lawrence Berkeley National Laboratory Report LBNL-54041.

**References**

Barnola, J.M., D. raymond, Y.S. Korotkevitch, and C. Lorius, 1987: Vostok ice core: A 160,000 year record of atmospheric $CO_2$, Nature, 329, 408-414.

Burnash, R.J., R.L. Feral, and R.A. McQuire, 1973: A generalized streamflow simulation system. In: Conceptualization modeling for digital computers. U.S. National Weather Service.

Ingram, B. L., Ingle, J. C., and Conrad, M. E. (1996) Isotopic records of Pre-historic salinity and river inflow in San Francisco Bay Estuary, in San Francisco Bay: The Ecosystem (J. T. Hollibaugh, Ed.), Amer. Assoc. for the Advancement of Science, Pacific Division, San Francisco, CA, 35-61.

Intergovernmental Panel on Climate Change, 2001: Climate Change 2001: The Scientific Basis. Cambridge Univ. Press. 881pp.

Intergovernmental Panel on Climate Change, 1995: Climate Change 1995: The Science of Climate Change. Cambridge Univ. Press. 531pp.

Intergovernmental Panel on Climate Change, 1990: Climate Change: The IPCC Scientific Assessment. Cambridge Univ. Press. 362pp.

Jeton, A.E., M.D. Dettinger, and J.L. Smith, 1996: Potential effects of climate change on streamflow: Eastern and western slopes of the Sierra Nevada, California and Nevada. U.S. Geological Survey, Water Res. Investigations Rep. 95-4260, 44pp.

Keeling, C.D., R.B. Bacastow, A.F. Carter, S.C. Piper, T.P. Whorf, M. Heimann, W.G. Mook, and H. Roeloffzen, 1989: A three dimensional model of atmospheric $CO_2$ transport based on observed winds: 1. Analysis of observational data. In: Aspects of climate variability in the Pacific and Western Americas. Peterson (ed.), Geophysical Monograph, 55, AGU, 165-236.

Knowles, N. and Cayan, D. R., 2002. Potential effects of global warming on the Sacramento/San Joaquin watershed and the San Francisco estuary. Geophys. Research Letters, 29, 1891.

Lettenmaier, D.P. and T.Y. Gan, 1990: Hydrologic sensitivities of the Sacramento-San Joaquin River Basin, California, to global warming. Water Resources Res, 26, 69-86.

Miller, N.L. and J. Kim, 1996: Numerical prediction of precipitation and river flow over the Russian River watershed during the January 1995 California storms. Bulletin Amer. Meteorological Soc. 77, 101-105.

Miller, N.L. and J. Kim 1997: The Regional Climate System Model. In Mission Earth: Modeling and Simulation for a Sustainable Global System. Ed. M. Clymer and C. Mechoso, Soc. Comp. Sim. Inter., 55-60.

Miller, N.L., J. Kim, R.K. Hartman, and J. Farrara, 1999: Downscaled climate and streamflow study of the Southwestern United States. J. Amer. Water Resources Assoc, 35, 1525-1537.

Miller, N.L., K.E. Bashford, E. Strem, 2003: Potential impacts of climate change on California hydrology. J. American Water Resources Association, 39, 771-784.

Miller, N.L., A. A.W. King, M.L. Wesely and others, 2003:The U.S. Department of Energy Water Cycle Pilot Study. Bulletin of the American Meteorological Society, In Review.

Wigley, T.M.L. and S.B.C. and Raper, 2001: interpretation of high projections of global-mean warming. Science, 293, 451-454.

Wilby, R.L. and M.D. Dettinger, 2000: Streamflow changes in the Sierra Nevada, California, simulated using statistically downscaled general circulation model output. In: Linking Climate Change to Land Surface Change, Ed. McLaren and Kniven, Kluwer Academic Pub., 99-121.

Wilkinson, R. and others, 2002: Preparing for a climate change: California. Report of the California Regional Assessment Group, U.S. Global Change Research Program. 850pp.

Attachment 29

# 14

# North America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**This chapter should be cited as:**
Field, C.B., L.D. Mortsch,, M. Brklacich, D.L. Forbes, P. Kovacs, J.A. Patz, S.W. Running and M.J. Scott, 2007: North America. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 617-652.

# Table of Contents


**Executive summary** ..... 619

**14.1 Introduction** ..... 619

14.1.1 Key findings from Third Assessment Report (TAR) ..... 620

14.1.2 Key differences from TAR ..... 620

**14.2 Current sensitivity/vulnerability** ..... 620

14.2.1 Freshwater resources ..... 621

14.2.2 Ecosystems ..... 622

14.2.3 Coastal regions ..... 622

Box 14.1 Accelerating wildfire and ecosystem disturbance dynamics ..... 623

14.2.4 Agriculture, forestry and fisheries ..... 623

14.2.5 Human health ..... 625

14.2.6 Human settlements ..... 625

14.2.7 Tourism and recreation ..... 626

14.2.8 Energy, industry and transportation ..... 626

**14.3 Assumptions about future trends** ..... 626

14.3.1 Climate ..... 626

14.3.2 Social, economic and institutional context ..... 627

**14.4 Key future impacts and vulnerabilities** ..... 627

14.4.1 Freshwater resources ..... 627

Box 14.2 Climate change adds challenges to managing the Columbia River system ..... 628

14.4.2 Ecosystems ..... 629

14.4.3 Coastal regions ..... 630

14.4.4 Agriculture, forestry and fisheries ..... 631

14.4.5 Human health ..... 632

14.4.6 Human settlements ..... 632

Box 14.3 North American cities integrate impacts across multiple scales and sectors ..... 633

14.4.7 Tourism and recreation ..... 634

14.4.8 Energy, industry and transportation ..... 634

14.4.9 Interacting impacts ..... 635

**14.5 Adaptation: practices, options and constraints** ..... 635

14.5.1 Practices and options ..... 636

14.5.2 Mainstreaming adaptation ..... 637

14.5.3 Constraints and opportunities ..... 638

**14.6 Case studies** ..... 639

**14.7 Conclusions: implications for sustainable development** ..... 639

**14.8 Key uncertainties and research priorities** ..... 639

**References** ..... 640

## Executive summary

**North America has experienced locally severe economic damage, plus substantial ecosystem, social and cultural disruption from recent weather-related extremes, including hurricanes, other severe storms, floods, droughts, heatwaves and wildfires (very high confidence).**
Over the past several decades, economic damage from severe weather has increased dramatically, due largely to increased value of the infrastructure at risk. Annual costs to North America have now reached tens of billions of dollars in damaged property and economic productivity, as well as lives disrupted and lost. [14.2.3, 14.2.6, 14.2.7, 14.2.8]

**The vulnerability of North America depends on the effectiveness and timing of adaptation and the distribution of coping capacity, which vary spatially and among sectors (very high confidence).**
Although North America has considerable adaptive capacity, actual practices have not always protected people and property from adverse impacts of climate variability and extreme weather events. Especially vulnerable groups include indigenous peoples and those who are socially or economically disadvantaged. Traditions and institutions in North America have encouraged a decentralised response framework where adaptation tends to be reactive, unevenly distributed, and focused on coping with rather than preventing problems. 'Mainstreaming' climate change issues into decision making is a key prerequisite for sustainability. [14.2.6, 14.4, 14.5, 14.7]

**Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution (very high confidence).**
Sea level is rising along much of the coast, and the rate of change will increase in the future, exacerbating the impacts of progressive inundation, storm-surge flooding and shoreline erosion. Storm impacts are likely to be more severe, especially along the Gulf and Atlantic coasts. Salt marshes, other coastal habitats, and dependent species are threatened by sea-level rise, fixed structures blocking landward migration, and changes in vegetation. Population growth and the rising value of infrastructure in coastal areas increases vulnerability to climate variability and future climate change. Current adaptation is uneven and readiness for increased exposure is low. [14.2.3, 14.4.3, 14.5]

**Climate change will constrain North America's over-allocated water resources, increasing competition among agricultural, municipal, industrial and ecological uses (very high confidence).**
Rising temperatures will diminish snowpack and increase evaporation, affecting seasonal availability of water. Higher demand from economic development, agriculture and population growth will further limit surface and groundwater availability. In the Great Lakes and major river systems, lower levels are likely to exacerbate challenges relating to water quality, navigation, recreation, hydropower generation, water transfers and bi-national relationships. [14.2.1, 14.4.1, 14.4.6, Boxes 14.2 and 14.3]

**Climate change impacts on infrastructure and human health and safety in urban centres will be compounded by ageing infrastructure, maladapted urban form and building stock, urban heat islands, air pollution, population growth and an ageing population (very high confidence).**
While inertia in the political, economic, and cultural systems complicates near-term action, the long life and high value of North American capital stock make proactive adaptation important for avoiding costly retrofits in coming decades. [14.4.5, 14.4.6, 14.5, Box 14.3]

**Without increased investments in countermeasures, hot temperatures and extreme weather are likely to cause increased adverse health impacts from heat-related mortality, pollution, storm-related fatalities and injuries, and infectious diseases (very high confidence).**
Historically important countermeasures include early warning and surveillance systems, air conditioning, access to health care, public education, vector control, infrastructure standards and air quality management. Cities that currently experience heatwaves are expected to experience an increase in intensity and duration of these events by the end of the century, with potential for adverse health effects. The growing number of the elderly is most at risk. Water-borne diseases and degraded water quality are very likely to increase with more heavy precipitation. Warming and climate extremes are likely to increase respiratory illness, including exposure to pollen and ozone. Climate change is likely to increase risk and geographic spread of vector-borne infectious diseases, including Lyme disease and West Nile virus. [14.2.5, 14.2.6, 14.4.5, 14.4.6, 14.5]

**Disturbances such as wildfire and insect outbreaks are increasing and are likely to intensify in a warmer future with drier soils and longer growing seasons (very high confidence).**
Although recent climate trends have increased vegetation growth, continuing increases in disturbances are likely to limit carbon storage, facilitate invasive species, and disrupt ecosystem services. Warmer summer temperatures are expected to extend the annual window of high fire ignition risk by 10-30%, and could result in increased area burned of 74-118% in Canada by 2100. Over the 21st century, pressure for species to shift north and to higher elevations will fundamentally rearrange North American ecosystems. Differential capacities for range shifts and constraints from development, habitat fragmentation, invasive species, and broken ecological connections will alter ecosystem structure, function and services. [14.2.4, 14.2.2, 14.4.2, Box 14.1]

## 14.1 Introduction

The United States (U.S.) and Canada will experience climate changes through direct effects of local changes (e.g., temperature, precipitation and extreme weather events), as well as through indirect effects, transmitted among regions by interconnected economies and migrations of humans and other species. Variations in wealth and geography, however, lead to an uneven distribution of likely impacts, vulnerabilities and capacities to adapt. This chapter reviews and synthesises the

state of knowledge on direct and indirect impacts, vulnerability and adaptations for North America (comprising Canada and the U.S.). Hawaii and other U.S. protectorates are discussed in Chapter 16 on Small Islands, and Mexico and Central America are treated in Chapter 13 on Latin America. Chapter 15, Polar Regions, covers high-latitude issues and peoples.

### 14.1.1 Key findings from the Third Assessment Report (TAR)

Key findings for the North America chapter of the Third Assessment Report (TAR) (Cohen et al., 2001) are:

*Resources and ecosystems*

- In western snowmelt-dominated watersheds, shifts in seasonal runoff, with more runoff in winter. Adaptation may not fully offset effects of reduced summer water availability.
- Changes in the abundance and spatial distribution of species important to commercial and recreational fisheries.
- Benefits from warming for food production in North America but with strong regional differences.
- Benefits from farm- and market-level adjustments in ameliorating impacts of climate change on agriculture.
- Increases in the area and productivity of forests, though carbon stocks could increase or decrease.
- Major role of disturbance for forest ecosystems. The forest-fire season is likely to lengthen, and the area subject to high fire danger is likely to increase significantly.
- Likely losses of cold-water ecosystems, high alpine areas, and coastal and inland wetlands.

*Human settlements and health*

- Less extreme winter cold in northern cities. Across North America, cities will experience more extreme heat and, in some locations, rising sea levels and risk of storm surge, water scarcity, and changes in timing, frequency, and severity of flooding.
- The need for changes in land-use planning and infrastructure design to avoid increased damages from heavy precipitation events.
- For communities that have the necessary resources, reduced vulnerability by adapting infrastructure.
- Increased deaths, injuries, infectious diseases, and stress-related disorders and other adverse effects associated with social disruption and migration from more frequent extreme weather.
- Increased frequency and severity of heatwaves leading to more illness and death, particularly among the young, elderly and frail. Respiratory disorders may be exacerbated by warming-induced deterioration in air quality.
- Expanded ranges of vector-borne and tick-borne diseases in North America but with modulation by public health measures and other factors.

*Vulnerability and adaptation*

- Increased weather-related losses in North America since the 1970s, with rising insured losses reflecting growing affluence and movement into vulnerable areas.
- Coverage, since the 1980s, by disaster relief and insurance programmes of a large fraction of flood and crop losses, possibly encouraging more human activity in at-risk areas.
- Responses by insurers to recent extreme events through limiting insurance availability, increasing prices and establishing new risk-spreading mechanisms. Improving building codes, land-use planning and disaster preparedness also reduce disaster losses.
- Awareness that developing adaptation responses requires a long, interdisciplinary dialogue between researchers and stakeholders, with substantial changes in institutions and infrastructure.
- Recognition that adaptation strategies generally address current challenges, rather than future impacts and opportunities.

### 14.1.2 Key differences from TAR

This assessment builds on the findings from the TAR and incorporates new results from the literature, including:

- Prospects for increased precipitation variability, increasing challenges of water management.
- The need to include groundwater and water-quality impacts in the assessment of water resources.
- The potential that multi-factor impacts may interact non-linearly, leading to tipping points.
- The potential importance of interactions among climate change impacts and with other kinds of local, regional and global changes.
- The potential for adaptation, but the unevenness of current adaptations.
- The challenge of linking adaptation strategies with future vulnerabilities.
- Availability of much more literature on all aspects of impacts, adaptation and vulnerability in North America.

## 14.2 Current sensitivity/vulnerability

Annual mean air temperature, on the whole, increased in North America for the period 1955 to 2005, with the greatest warming in Alaska and north-western Canada, substantial warming in the continental interior and modest warming in the south-eastern U.S. and eastern Canada (Figure 14.1). Spring and winter show the greatest changes in temperature (Karl et al., 1996; Hengeveld et al., 2005) and daily minimum (night-time) temperatures have warmed more than daily maximum (daytime) temperatures (Karl et al., 2005; Vincent and Mekis, 2006). The length of the vegetation growing season has increased an average of 2 days/decade since 1950 in Canada and the conterminous U.S., with most of the increase resulting from earlier spring warming (Bonsal et al., 2001; Easterling, 2002; Bonsal and Prowse, 2003; Feng and Hu, 2004). The warming signal in North America during the latter half of the 20th century reflects the combined influence of greenhouse gases, sulphate aerosols and natural external forcing (Karoly et al., 2003; Stott, 2003; Zwiers and Zhang, 2003).

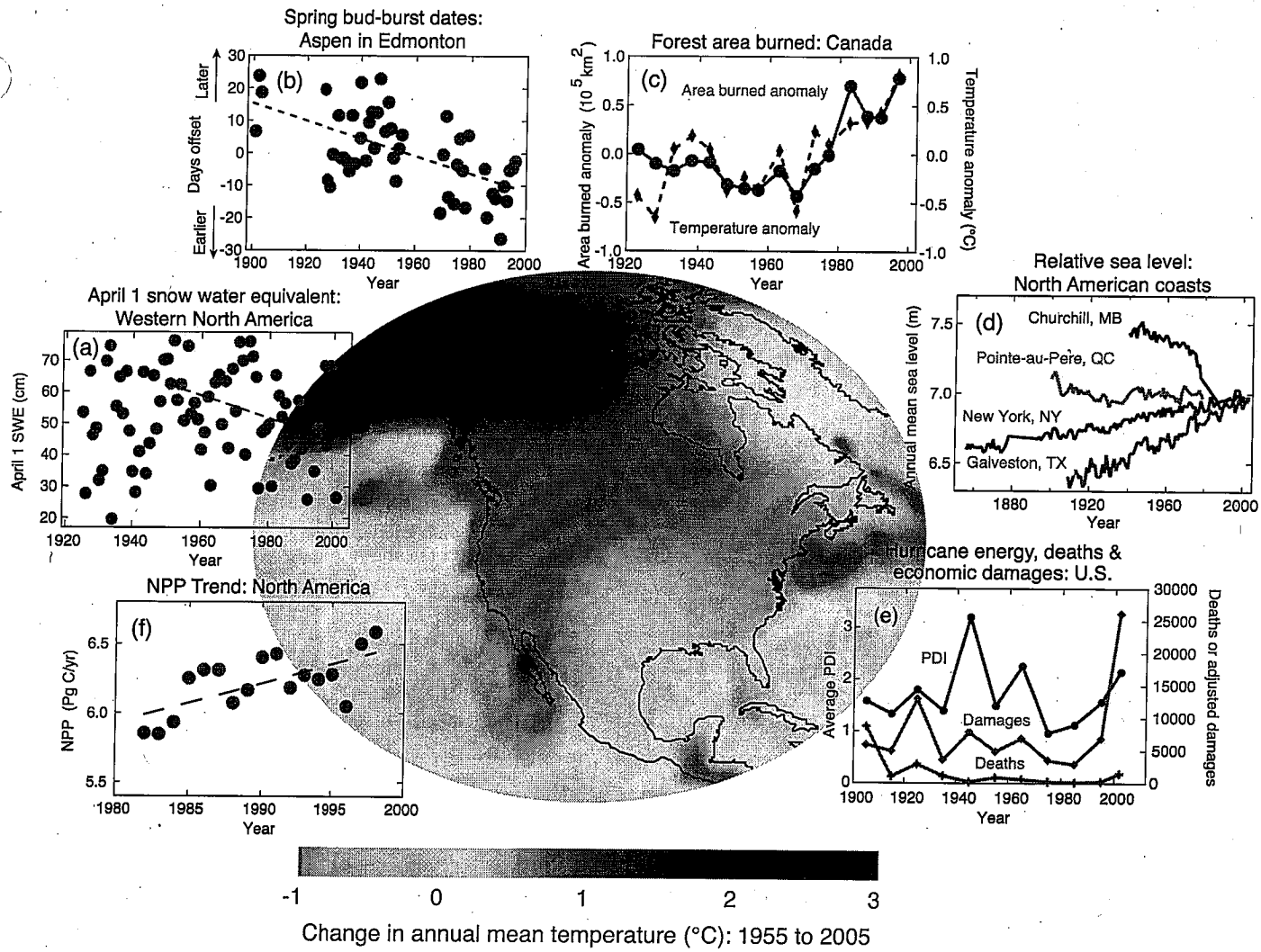


**Figure 14.1.** *Observed trends in some biophysical and socio-economic indicators. Background: change in annual mean temperature from 1955 to 2005 (based on the GISS2001 analysis for land from Hansen et al., 2001; and on the Hadley/Reyn_V2 analysis for sea surface from Reynolds et al., 2002). Insets: (a) trend in April 1 snow water equivalent (SWE) across western North America from 1925 to 2002, with a linear fit from 1950 to 2002 (data from Mote, 2003), (b) Spring bud-burst dates for trembling aspen in Edmonton since 1900 (data from Beaubien and Freeland, 2000), (c) anomaly in 5-year mean area burned annually in wildfires in Canada since 1930, plus observed mean summer air temperature anomaly, weighted for fire areas, relative to 1920 to 1999 (data from Gillett et al., 2004) (d) relative sea-level rise from 1850 to 2000 for Churchill, MB, Pointe-au-Père, QB, New York, NY, and Galveston, TX, (POL, 2006) (e) hurricane energy (power dissipation index (PDI) based on method of Emanuel, 2005), economic damages, million U.S. dollars (adjusted to constant 2005 US dollars and normalized accounting for changes in personal wealth and coastal population to 2004), and deaths from Atlantic hurricanes since 1900 (data from Pielke Jr. and Landsea, 1998 updated through 2005), and, (f) trend North American Net Primary Production (NPP) from 1981 to 1998 (data from Hicke et al., 2002).*

Annual precipitation has increased for most of North America with large increases in northern Canada, but with decreases in the south-west U.S., the Canadian Prairies and the eastern Arctic (see Working Group I Fourth Assessment (WGI AR4) Trenberth et al., 2007 Section 3.3.2.2, Figures 3.13 and 3.14) (Hengeveld et al., 2005; Shein, 2006). Heavy precipitation frequencies in the U.S. were at a minimum in the 1920s and 1930s, and increased to the 1990s (1895 to 2000) (Kunkel, 2003; Groisman et al., 2004). In Canada there is no consistent trend in extreme precipitation (Vincent and Mekis, 2006).

### 14.2.1 Freshwater resources

Streamflow in the eastern U.S. has increased 25% in the last 60 years (Groisman et al., 2004), but over the last century has decreased by about 2%/decade in the central Rocky Mountain region (Rood et al., 2005). Since 1950, stream discharge in both the Colorado and Columbia river basins has decreased, at the same time annual evapotranspiration (ET) from the conterminous U.S. increased by 55 mm (Walter et al., 2004). In regions with winter snow, warming has shifted the magnitude

and timing of hydrologic events (Mote et al., 2005; Regonda et al., 2005; Stewart et al., 2005). The fraction of annual precipitation falling as rain (rather than snow) increased at 74% of the weather stations studied in the western mountains of the U.S. from 1949 to 2004 (Knowles et al., 2006). In Canada, warming from 1900 to 2003 led to a decrease in total precipitation as snowfall in the west and Prairies (Vincent and Mekis, 2006). Spring and summer snow cover has decreased in the U.S. west (Groisman et al., 2004). April 1 snow water equivalent (SWE) has declined 15 to 30% since 1950 in the western mountains of North America, particularly at lower elevations and primarily due to warming rather than changes in precipitation (Figure 14.1a) (see Mote et al., 2003; Mote et al., 2005; Lemke et al., 2007: Section 4.2.2.2.1). Whitfield and Cannon (2000) and Zhang et al. (2001) reported earlier spring runoff across Canada. Summer (May to August) flows of the Athabasca River have declined 20% since 1958 (Schindler and Donahue, 2006). Streamflow peaks in the snowmelt-dominated western mountains of the U.S. occurred 1 to 4 weeks earlier in 2002 than in 1948 (Stewart et al., 2005). Break up of river and lake ice across North America has advanced by 0.2 to 12.9 days over the last 100 years (Magnuson et al., 2000).

Vulnerability to extended drought is increasing across North America as population growth and economic development create more demands from agricultural, municipal and industrial uses, resulting in frequent over-allocation of water resources (Alberta Environment, 2002; Morehouse et al., 2002; Postel and Richter, 2003; Pulwarty et al., 2005). Although drought has been more frequent and intense in the western part of the U.S. and Canada, the east is not immune from droughts and attendant reductions in water supply, changes in water quality and ecosystem function, and challenges in allocation (Dupigny-Giroux, 2001; Bonsal et al., 2004; Wheaton et al., 2005).

### 14.2.2 Ecosystems

Three clear, observable connections between climate and terrestrial ecosystems are the seasonal timing of life-cycle events or phenology, responses of plant growth or primary production, and biogeographic distribution. Direct impacts on organisms interact with indirect effects of ecological mechanisms (competition, herbivory[1], disease), and disturbance (wildfire, hurricanes, human activities).

*Phenology, productivity and biogeography*

Global daily satellite data, available since 1981, indicate earlier onset of spring 'greenness' by 10-14 days over 19 years, particularly across temperate latitudes of the Northern Hemisphere (Myneni et al., 2001; Lucht et al., 2002). Field studies confirm these satellite observations. Many species are expanding leaves or flowering earlier (e.g., earlier flowering in lilac - 1.8 days/decade, 1959 to 1993, 800 sites across North America (Schwartz and Reiter, 2000), honeysuckle - 3.8 days/decade, western U.S. (Cayan et al., 2001), and leaf expansion in apple and grape - 2 days/decade, 72 sites in north-eastern U.S. (Wolfe et al., 2005), trembling aspen - 2.6 days/decade since 1900, Edmonton (Beaubien and Freeland, 2000)) (Figure 14.1b). The timing of autumn leaf fall, which is controlled by a combination of temperature, photoperiod and water deficits, shows weaker trends (Badeck et al., 2004).

Net primary production (NPP) in the continental U.S. increased nearly 10% from 1982 to 1998 (Figure 14.1f) (Boisvenue and Running, 2006), with the largest increases in croplands and grasslands of the Central Plains due to improved water balance (Lobell et al., 2002; Nemani et al., 2002; Hicke and Lobell, 2004).

North American forests can be influenced indirectly by climate through effects on disturbance, especially from wildfire, storms, insects and diseases. The area burned in wildfires has increased dramatically over the last three decades (see Box 14.1).

*Wildlife population and community dynamics*

North American animals are responding to climate change, with effects on phenology, migration, reproduction, dormancy and geographic range (Walther et al., 2002; Parmesan and Yohe, 2003; Root et al., 2003; Parmesan and Galbraith, 2004; Root et al., 2005). Warmer springs have led to earlier nesting for 28 migrating bird species on the east coast of the U.S. (Butler, 2003) and to earlier egg laying for Mexican jays (Brown et al., 1999) and tree swallows (Dunn and Winkler, 1999). In northern Canada, red squirrels are breeding 18 days earlier than 10 years ago (Reale et al., 2003). Several frog species now initiate breeding calls 10 to 13 days earlier than a century ago (Gibbs and Breisch, 2001). In lowland California, 70% of 23 butterfly species advanced the date of first spring flights by an average 24 days over 31 years (Forister and Shapiro, 2003). Reduced water depth, related to recent warming, in Oregon lakes has increased exposure of toad eggs to UV-B, leading to increased mortality from a fungal parasite (Kiesecker et al., 2001; Pounds, 2001).

Many North American species have shifted their ranges, typically to the north or to higher elevations (Parmesan and Yohe, 2003). Edith's checkerspot butterfly has become locally extinct in the southern, low-elevation portion of its western North American range but has extended its range 90 km north and 120 m higher in elevation (Parmesan, 1996; Crozier, 2003; Parmesan and Galbraith, 2004). Red foxes have expanded northward in northern Canada, leading to retreat of competitively subordinate arctic foxes (Hersteinsson and Macdonald, 1992).

### 14.2.3 Coastal regions

The North American coast is long and diverse with a wide range of trends in relative sea level (Figure 14.1d) (Shaw et al., 1998; Dyke and Peltier, 2000; Zervas, 2001). Relative sea level (see glossary) is rising in many areas, yet coastal residents are often unaware of the trends and their impacts on coastal retreat and flooding (O'Reilly et al., 2005). In the Great Lakes, both extremely high and extremely low water levels have been damaging and disruptive (Moulton and Cuthbert, 2000). Demand for waterfront property and building land continues to grow, increasing the value of property at risk (Heinz Center, 2000; Forbes et al., 2002b; Small and Nichols, 2003).

[1] The consumption of plants by animals.

## Box 14.1. Accelerating wildfire and ecosystem disturbance dynamics

Since 1980, an average of 22,000 km²/yr has burned in U.S. wildfires, almost twice the 1920 to 1980 average of 13,000 km²/yr (Schoennagel et al., 2004). The forested area burned in the western U.S. from 1987 to 2003 is 6.7 times the area burned from 1970 to 1986 (Westerling et al., 2006). In Canada, burned area has exceeded 60,000 km²/yr three times since 1990, twice the long-term average (Stocks et al., 2002). Wildfire-burned area in the North American boreal region increased from 6,500 km²/yr in the 1960s to 29,700 km²/yr in the 1990s (Kasischke and Turetsky, 2006). Human vulnerability to wildfires has also increased, with a rising population in the wildland-urban interface.

A warming climate encourages wildfires through a longer summer period that dries fuels, promoting easier ignition and faster spread (Running, 2006). Westerling et al. (2006) found that in the last three decades the wildfire season in the western U.S. has increased by 78 days, and burn durations of fires >1000 ha in area have increased from 7.5 to 37.1 days, in response to a spring-summer warming of 0.87°C. Earlier spring snowmelt has led to longer growing seasons and drought, especially at higher elevations, where the increase in wildfire activity has been greatest (Westerling et al., 2006). In Canada, warmer May to August temperatures of 0.8°C since 1970 are highly correlated with area burned (Figure 14.1c) (Gillett et al., 2004). In the south-western U.S., fire activity is correlated with El Niño-Southern Oscillation (ENSO) positive phases (Kitzberger et al., 2001; McKenzie et al., 2004), and higher Palmer Drought Severity Indices.

Insects and diseases are a natural part of ecosystems. In forests, periodic insect epidemics kill trees over large regions, providing dead, desiccated fuels for large wildfires. These epidemics are related to aspects of insect life cycles that are climate sensitive (Williams and Liebhold, 2002). Many northern insects have a two-year life cycle, and warmer winter temperatures allow a larger fraction of overwintering larvae to survive. Recently, spruce budworm in Alaska has completed its life cycle in one year, rather than the previous two (Volney and Fleming, 2000). Mountain pine beetle has expanded its range in British Columbia into areas previously too cold (Carroll et al., 2003). Insect outbreaks often have complex causes. Susceptibility of the trees to insects is increased when multi-year droughts degrade the trees' ability to generate defensive chemicals (Logan et al., 2003). Recent dieback of aspen stands in Alberta was caused by light snowpacks and drought in the 1980s, triggering defoliation by tent caterpillars, followed by wood-boring insects and fungal pathogens (Hogg et al., 2002).

Many coastal areas in North America are potentially exposed to storm-surge flooding (Titus and Richman, 2001; Titus, 2005). Some major urban centres on large deltas are below sea level (e.g., New Orleans on the Mississippi; Richmond and Delta on the Fraser), placing large populations at risk. Breaching of New Orleans floodwalls following Hurricane Katrina in 2005 (see Chapter 6, Section 6.4.1.2 and Box 6.4) and storm-wave breaching of a dike in Delta, British Columbia, in 2006 demonstrate the vulnerability. Under El Niño conditions, high water levels combined with changes in winter storms along the Pacific coast have produced severe coastal flooding and storm impacts (Komar et al., 2000; Walker and Barrie, 2006). At San Francisco, 140 years of tide-gauge data suggest an increase in severe winter storms since 1950 (Bromirski et al., 2003) and some studies have detected accelerated coastal erosion (Bernatchez and Dubois, 2004). Some Alaskan villages are threatened and require protection or relocation at projected costs up to US$54 million (Parson et al., 2001a). Recent severe tropical and extra-tropical storms demonstrate that North American urban centres with assumed high adaptive capacity remain vulnerable to extreme events. Recent winters with less ice in the Great Lakes and Gulf of St. Lawrence have increased coastal exposure to damage from winter storms. Winter ice provides seasonal shore protection, but can also damage shorefront homes and infrastructure (Forbes et al., 2002a).

Impacts on coastal communities and ecosystems can be more severe when major storms occur in short succession, limiting the opportunity to rebuild natural resilience (Forbes et al., 2004). Adaptation to coastal hazards under the present climate is often inadequate, and readiness for increased exposure is poor (Clark et al., 1998; Leatherman, 2001; West et al., 2001). Extreme events can add to other stresses on ecological integrity (Scavia et al., 2002; Burkett et al., 2005), including shoreline development and nitrogen eutrophication[2] (Bertness et al., 2002). Already, more than 50% of the original salt marsh habitat in the U.S. has been lost (Kennish, 2001). Impacts from sea-level rise can be amplified by 'coastal squeeze' (see Glossary) and submergence where landward migration is impeded and vertical growth is slower than sea-level rise (see Section 14.4.3) (Kennish, 2001; Scavia et al., 2002; Chmura and Hung, 2004).

### 14.2.4 Agriculture, forestry and fisheries

*Agriculture*

Over the last century, yields of major commodity crops in the U.S. have increased consistently, typically at rates of 1 to 2%/yr (Troyer, 2004), but there are significant variations across regions and between years. These yield trends are a result of cumulative changes in multiple factors, including technology, fertiliser use,

[2] Eutrophication is a process whereby water bodies, such as lakes, estuaries, or slow-moving streams receive excess nutrients that stimulate excessive plant growth (e.g., algal blooms and nuisance plants weeds).

seed stocks, and management techniques, plus any changes due to climate; the specific impact from any one factor may be positive or negative. In the Midwestern U.S. from 1970 to 2000, corn yield increased 58% and soybean yields increased 20%, with annual weather fluctuations resulting in year-to-year variability (Hicke and Lobell, 2004). Heavy rainfalls reduced the value of the U.S. corn crop by an average of US$3 billion/yr between 1951 and 1998 (Rosenzweig et al., 2002). In the Corn and Wheat Belt of the U.S., yields of corn and soybeans from 1982 to 1998 were negatively impacted by warm temperatures, decreasing 17% for each 1°C of warm-temperature anomaly (Lobell and Asner, 2003). In California, warmer nights have enhanced the production of high-quality wine grapes (Nemani et al., 2001), but additional warming may not result in similar increases. For twelve major crops in California, climate fluctuations over the last 20 years have not had large effects on yield, though they have been a positive factor for oranges and walnuts and a negative for avocados and cotton (Lobell et al., 2006).

North American agriculture has been exposed to many severe weather events during the past decade. More variable weather, coupled with out-migration from rural areas and economic stresses, has increased the vulnerability of the agricultural sector overall, raising concerns about its future capacity to cope with a more variable climate (Senate of Canada, 2003; Wheaton et al., 2005). North American agriculture is, however, dynamic. Adaptation to multiple stresses and opportunities, including changes in markets and weather, is a normal process for the sector. Crop and enterprise diversification, as well as soil and water conservation, are often used to reduce weather-related risks (Wall and Smit, 2005). Recent adaptations by the agricultural sector in North America, including improved water conservation and conservation tillage, are not typically undertaken as single discrete actions, but evolve as a set of decisions that can span several years in a dynamic and changing environment (Smit and Skinner, 2002) that includes changes in public policy (Goodwin, 2003). While there have been attempts to realistically model the dynamics of adaptation to climate change (Easterling et al., 2003), understanding of agriculture's current sensitivity to climate variability and its capacity to cope with climate change remains limited (Tol, 2002).

*Forestry*

Forest growth appears to be slowly accelerating (at a rate of less than 1%/decade) in regions where tree growth has historically been limited by low temperatures and short growing seasons (Caspersen et al., 2000; McKenzie et al., 2001; Joos et al., 2002; Boisvenue and Running, 2006). In black spruce at the forest-tundra transition in eastern Canada, height growth has been increasing since the 1970s (Gamache and Payette, 2004). Growth is slowing, however, in areas subject to drought. Radial growth of white spruce on dry south-facing slopes in Alaska has decreased over the last 90 years, due to increased drought stress (Barber et al., 2000). In semi-arid forests of the south-western U.S., growth rates have decreased since 1895, correlated with drought linked to warming temperatures (McKenzie et al., 2001). Relationships between tree-ring growth in sub-alpine forests and climate in the Pacific Northwest from 1895 to 1991 had complex topographic influences (Peterson and Peterson, 2001; Peterson et al., 2002). On high elevation north-facing slopes, growth of sub-alpine fir and mountain hemlock was negatively correlated with spring snowpack depth and positively correlated with summer temperatures, indicating growing-season temperature limitations. On lower elevation sites, however, growth was negatively correlated with summer temperature, suggesting water limitations. In Colorado, aspen have advanced into the more cold-tolerant spruce-fir forests over the past 100 years (Elliott and Baker, 2004). The northern range limit of lodgepole pine is advancing into the zone previously dominated by the more cold-tolerant black spruce in the Yukon (Johnstone and Chapin, 2003). A combination of warmer temperatures and insect infestations has resulted in economically significant losses of the forest resource base to spruce bark beetle in both Alaska and the Yukon (ACIA, 2004).

*Freshwater fisheries*

Most commercial freshwater fishing in North America occurs in rural or remote areas, with indigenous peoples often taking a major role. Recreational inland fisheries are also significant and increasing (DFO-MPO, 2002; DOI, 2002). Ecological sustainability of fish and fisheries productivity is closely tied to temperature and water supply (flows and lake levels). Climate change and variability increasingly have direct and indirect impacts, both of which interact with other pressures on freshwater fisheries, including human development (Schindler, 2001; Chu et al., 2003; Reed and Czech, 2005; Rose, 2005), habitat loss and alteration (including water pollution), biotic homogenisation due to invasions and introductions (Rahel, 2002), and over-exploitation (Post et al., 2002; Cooke and Cowx, 2004). Cold- and cool-water fisheries, especially Salmonids, have been declining as warmer/drier conditions reduce their habitat. The sea-run[3] salmon stocks are in steep decline throughout much of North America (Gallagher and Wood, 2003). Evidence for impacts of recent climate change is rapidly accumulating. Pacific salmon have been appearing in Arctic rivers (Babaluk et al., 2000). Salmonid species have been affected by warming in U.S. streams (O'Neal, 2002). Lake charr in an Ontario lake suffered recruitment[4] failure due to El Niño-linked warm temperatures (Gunn, 2002). Lake Ontario year-class productivity is strongly linked to temperature, with a shift in the 1990s toward warm-water species (Casselman, 2002). Walleye yield in lakes depends on the amount of cool, turbid habitat (Lester et al., 2004). Recent contraction in habitat for walleye in the Bay of Quinte, Lake Ontario was due in part to warming and lower water levels (Chu et al., 2005). Success of adult spawning and survival of the fry (new-borne) of brook trout is closely linked to cold groundwater seeps, which provide preferred temperature refuges for lake-dwelling populations (Borwick et al., 2006). Rates of fish-egg development and mortality increase with temperature rise within species-specific tolerance ranges (Kamler, 2002).

[3] Sea-run: having the habit of ascending a river from the sea, especially to spawn.
[4] Recruitment: the number of new juvenile fish reaching a size large enough to be caught by commercial fishing methods.

### 14.2.5 Human health

Many human diseases are sensitive to weather, from cardiovascular and respiratory illnesses due to heatwaves or air pollution, to altered transmission of infectious diseases. Synergistic effects of other activities can exacerbate weather exposures (e.g., via the urban heat island effect), requiring cross-sector risk assessment to determine site-specific vulnerability (Patz et al., 2005).

The incidence of infectious diseases transmitted by air varies seasonally and annually, due partly to climate variations. In the early 1990s, California experienced an epidemic of Valley Fever that followed five years of drought (Kolivras and Comrie, 2003). Water-borne disease outbreaks from all causes in the U.S. are distinctly seasonal, clustered in key watersheds, and associated with heavy precipitation (in the U.S. Curriero et al., 2001) or extreme precipitation and warmer temperatures (in Canada, Thomas et al., 2006). Heavy runoff after severe rainfall can also contaminate recreational waters and increase the risk of human illness (Schuster et al., 2005) through higher bacterial counts. This association is strongest at beaches closest to rivers (Dwight et al., 2002).

Food-borne diseases show some relationship with historical temperature trends. In Alberta, ambient temperature is strongly but non-linearly associated with the occurrence of three enteric pathogens, *Salmonella, E. coli* and *Campylobacter* (Fleury et al., 2006).

Many zoonotic diseases[5] are sensitive to climate fluctuations (Charron, 2002). The strain of West Nile virus (WNV) that emerged for the first time in North America during the record hot July 1999 requires warmer temperatures than other strains. The greatest WNV transmissions during the epidemic summers of 2002 to 2004 in the U.S. were linked to above-average temperatures (Reisen et al., 2006). Laboratory studies of virus replication in WNV's main *Culex* mosquito vector show high levels of virus at warmer temperatures (Dohm and Turell, 2001; Dohm et al., 2002). Bird migratory pathways and WNV's recent advance westward across the U.S. and Canada are key factors in WNV and must be considered in future assessments of the role of temperature in WNV dynamics. A virus closely related to WNV, Saint Louis encephalitis, tends to appear during hot, dry La Niña years, when conditions facilitate transmission by reducing the extrinsic incubation period[6] (Cayan et al., 2003).

Lyme disease is a prevalent tick-borne disease in North America for which there is new evidence of an association with temperature (Ogden et al., 2004) and precipitation (McCabe and Bunnell, 2004). In the field, temperature and vapour pressure contribute to maintaining populations of the tick *Ixodes scapularis* which, in the U.S., is the micro-organism's secondary host. A monthly average minimum temperature above -7°C is required for tick survival (Brownstein et al., 2003).

Exposure to both extreme hot and cold weather is associated with increased morbidity and mortality, compared to an intermediate 'comfortable' temperature range (Curriero et al., 2002). Across 12 U.S. cities, hot temperatures have been associated with increased hospital admissions for cardiovascular disease (Schwartz et al., 2004a). Emergency hospital admissions have been directly related to extreme heat in Toronto (Dolney and Sheridan, 2006). Heat-response plans and heat early warning systems (EWS) can save lives (Ebi et al., 2004). After the 1995 heatwave, the city of Milwaukee initiated an 'extreme heat conditions plan' that almost halved heat-related morbidity and mortality (Weisskopf et al., 2002). Currently, over two dozen cities worldwide have warning systems focused on monitoring for dangerous air masses (Sheridan and Kalkstein, 2004).

### 14.2.6 Human settlements

*Economic base of resource-dependent communities*

Among the most climate-sensitive North American communities are those of indigenous populations dependent on one or a few natural resources. About 1.2 million (60%) of the U.S. tribal members live on or near reservations, and many pursue lifestyles with a mix of traditional subsistence activities and wage labour (Houser et al., 2001). Many reservation economies and budgets of indigenous governments depend heavily on agriculture, forest products and tourism (NAST, 2001). A 1993 hantavirus outbreak related indirectly to heavy rainfall led to a significant reduction in tourist visits to the American South-west (NAST, 2001). Many indigenous communities in northern Canada and Alaska are already experiencing constraints on lifestyles and economic activity from less reliable sea and lake ice (for travelling, hunting, fishing and whaling), loss of forest resources from insect damage, stress on caribou, and more exposed coastal infrastructure from diminishing sea ice (NAST, 2001; CCME, 2003; ACIA, 2005). Many rural settlements in North America, particularly those dependent on a narrow resource base, such as fishing or forestry, have been seriously affected by recent declines in the resource base, caused by a number of factors (CDLI, 1996). However, not all communities have suffered, as some Alaskan fishing communities have benefited from rising regional abundance of selected salmon stocks since the mid-1970s (Eggers, 2006).

*Infrastructure and extreme events*

About 80% of North Americans live in urban areas (Census Bureau, 2000; Statistics Canada, 2001b). North American cities, while diverse in size, function, climate and other factors, are largely shielded from the natural environment by technical systems. The devastating effects of hurricanes Ivan in 2004 and Katrina, Rita and Wilma in 2005, however, illustrate the vulnerability of North American infrastructure and urban systems that were either not designed or not maintained to adequate safety margins. When protective systems fail, impacts can be widespread and multi-dimensional (see Chapter 7, Boxes 7.2 and 7.4). Disproportionate impacts of Hurricane Katrina on the poor, infirm, elderly, and other dependent populations were amplified by inadequate public sector development and/or

[5] Zoonotic diseases: diseases caused by infectious agents that can be transmitted between (or are shared by) animals and humans.

[6] Extrinsic incubation period: the interval between the acquisition of an infectious agent by a vector and the vector's ability to transmit the agent to other hosts.

execution of evacuation and emergency services plans (Select Bipartisan Committee, 2006).

Costs of weather-related natural disasters in North America rose at the end of the 20th century, mainly as a result of the increasing value of infrastructure at risk (Changnon, 2003, 2005). Key factors in the increase in exposure include rising wealth, demographic shifts to coastal areas, urbanisation in storm-prone areas, and ageing infrastructure, combined with substandard structures and inadequate building codes (Easterling et al., 2000; Balling and Cerveny, 2003; Changnon, 2003, 2005). Trends in the number and intensity of extreme events in North America are variable, with many (e.g., hail events, tornadoes, severe windstorms, winter storms) holding steady or even decreasing (Kunkel et al., 1999; McCabe et al., 2001; Balling and Cerveny, 2003; Changnon, 2003; Trenberth et al., 2007: Section 3.8.4.2).

North America very likely will continue to suffer serious losses of life and property simply due to growth in property values and numbers of people at risk (very high confidence) (Pielke Jr., 2005; Pielke et al., 2005). Of the US$19 trillion value of all insured residential and commercial property in the U.S. states exposed to North Atlantic hurricanes, US$7.2 trillion (41%) is located in coastal counties. This economic value includes 79% of the property in Florida, 63% of the property in New York, and 61% of the property in Connecticut (AIR, 2002). Cumulative decadal hurricane intensity in the U.S. has risen in the last 25 years, following a peak in the mid 20th century and a later decline (Figure 14.1e). North American mortality (deaths and death rates) from hurricanes, tornadoes, floods and lightning have generally declined since the beginning of the 20th century, due largely to improved warning systems (Goklany, 2006). Mortality was dominated by three storms where the warning/evacuation system did not lead to timely evacuation: Galveston in 1900, Okeechobee in 1926, and Katrina in 2005.

Flood hazards are not limited to the coastal zone. River basins with a history of major floods (e.g., the Sacramento (Miller, 2003), the Fraser (Lemmen and Warren, 2004), the Red River (Simonovic and Li, 2004) and the upper Mississippi (Allen et al., 2003)) illustrate the sensitivity of riverine flooding to extreme events and highlight the critical importance of infrastructure design standards, land-use planning and weather/flood forecasts.

### 14.2.7 Tourism and recreation

The U.S. and Canada rank among the top ten nations for international tourism receipts (US$112 billion and US$16 billion, respectively) with domestic tourism and outdoor recreation markets that are several times larger (World Tourism Organization, 2002; Southwick Associates, 2006). Climate variability affects many segments of this growing economic sector. For example, wildfires in Colorado (2002) and British Columbia (2003) caused tens of millions of dollars in tourism losses by reducing visitation and destroying infrastructure (Associated Press, 2002; Butler, 2002; BC Stats, 2003). Similar economic losses were caused by drought-affected water levels in rivers and reservoirs in the western U.S. and parts of the Great Lakes (Fisheries and Oceans Canada, 2000; Kesmodel, 2002; Allen, 2003). The ten-day closure and clean-up following Hurricane Georges (September 1998) resulted in tourism revenue losses of approximately US$32 million in the Florida Keys (EPA, 1999). While the North American tourism industry acknowledges the important influence of climate, its impacts have not been analysed comprehensively (Scott et al., 2006).

### 14.2.8 Energy, industry and transportation

North American industry, energy supply and transportation networks are sensitive to weather extremes that exceed their safety margins. Costs of these impacts can be high. For example, power outages in the U.S. cost the economy US$30 billion to 130 billion annually (EPRI, 2003; LaCommare and Eto, 2004). The hurricanes crossing Florida in the summer of 2004 resulted in direct system restoration costs of US$1.4 billion to the four Florida public utilities involved (EEI, 2005). From 1994 to 2004, fourteen U.S. utilities experienced 81 other major storms, which cost an average of US$49 million/storm, with the highest single storm impact of US$890 million (EEI, 2005).

Although it was not triggered specifically by the concurrent hot weather, the 2003 summer outage in north-eastern U.S. and south-eastern Canada illustrates costs to North American society that result from large-scale power interruptions during periods of high demand. Over 50 million people were without power, resulting in US$180 million in insured losses and up to US$10 billion in total losses (Fletcher, 2004). Business interruptions were particularly significant, with costs of over US$250,000/hr incurred by the top quartile of recently surveyed companies (RM, 2003).

The impacts of Hurricanes Katrina, Rita and Wilma in 2005 and Ivan in 2004 demonstrated that the Gulf of Mexico offshore oil and natural gas platforms and pipelines, petroleum refineries, and supporting infrastructure can be seriously harmed by major hurricanes, which can produce national-level impacts, and require recovery times stretching to months or longer (Business Week, 2005; EEA, 2005; EIA, 2005a; Levitan and Associates Inc., 2005; RMS, 2005b; Swiss Re, 2005b, c, d, e).

Hydropower production is known to be sensitive to total runoff, to its timing, and to reservoir levels. For example, during the 1990s, Great Lakes levels fell as a result of a lengthy drought, and in 1999 hydropower production was down significantly both at Niagara and Sault St. Marie (CCME, 2003).

## 14.3 Assumptions about future trends

### 14.3.1 Climate

Recent climate model simulations (Ruosteenoja et al., 2003) indicate that by the 2010 to 2039 time slice, year-round temperatures across North America will be outside the range of present-day natural variability, based on 1000 year Atmosphere-Ocean General Circulation Model (AOGCM) simulations with either the CGCM2 or HadCM3 climate models. For most combinations of model, scenario, season and region, warming in the 2010 to 2039 time slice will be in the range of 1 to 3°C.

Late in the century, projected annual warming is likely to be 2 to 3°C across the western, southern, and eastern continental edges, but more than 5°C at high latitudes (Christensen et al., 2007: Section 11.5.3.1). The projected warming is greatest in winter at high latitudes and greatest in the summer in the south-west U.S. Warm extremes across North America are projected to become both more frequent and longer (Christensen et al., 2007: Section 11.5.3.3).

Annual-mean precipitation is projected to decrease in the south-west of the U.S. but increase over the rest of the continent (Christensen et al., 2007: Section 11.5.3.2). Increases in precipitation in Canada are projected to be in the range of +20% for the annual mean and +30% for the winter. Some studies project widespread increases in extreme precipitation (Christensen et al., 2007: Section 11.5.3.3), with greater risks of not only flooding from intense precipitation, but also droughts from greater temporal variability in precipitation. In general, projected changes in precipitation extremes are larger than changes in mean precipitation (Meehl et al., 2007: Section 10.3.6.1)

Future trends in hurricane frequency and intensity remain very uncertain. Experiments with climate models with sufficient resolution to depict some aspects of individual hurricanes tend to project some increases in both peak wind speeds and precipitation intensities (Meehl et al., 2007: Section 10.3.6.3). The pattern is clearer for extra-tropical storms, which are likely to become more intense, but perhaps less frequent, leading to increased extreme wave heights in the mid-latitudes (Meehl et al., 2007: Section 10.3.6.4).

El Niño events are associated with increased precipitation and severe storms in some regions, such as the south-east U.S., and higher precipitation in the Great Basin of the western U.S., but warmer temperatures and decreased precipitation in other areas such as the Pacific Northwest, western Canada, and parts of Alaska (Ropelewski and Halpert, 1986; Shabbar et al., 1997). Recent analyses indicate no consistent future trends in El Niño amplitude or frequency (Meehl et al., 2007: Section 10.3.5.4).

### 14.3.2 Social, economic, and institutional context

Canada and the U.S. have developed economies with per capita gross domestic product (GDP) in 2005 of US$31,572 and US$37,371, respectively (UNECE, 2005a,b). Future population growth is likely to be dominated by immigration (Campbell, 1996). Interests of indigenous peoples are important in both Canada and the U.S., especially in relation to questions of land management. With ageing populations, the costs of health care are likely to climb over several decades (Burleton, 2002).

Major parts of the economies of Canada and the U.S. are directly sensitive to climate, including the massive agricultural (2005 value US$316 billion) (Economic Research Service, 2006; Statistics Canada, 2006), transportation (2004 value US$510 billion) (Bureau of Transportation Statistics, 2006; Industry Canada, 2006) and tourism sectors (see Section 14.2.4, 14.2.7 and 14.2.8). Although many activities have limited direct sensitivity to climate (Nordhaus, 2006), the potential realm of climate-sensitive activities expands with increasing evidence that storms, floods, or droughts increase in frequency or intensity with climate change (Christensen et al., 2007: Section 11.5.3.3 and Meehl et al., 2007: Sections 10.3.6.1 and 10.3.6.2).

The economies of Canada and the U.S. have large private and public sectors, with strong emphasis on free market mechanisms and the philosophy of private ownership. If strong trends toward globalisation in the last several decades continue through the 21st century, it is likely that the means of production, markets, and ownership will be predominantly international, with policies and governance increasingly designed for the international marketplace (Stiglitz, 2002).

## 14.4 Key future impacts and vulnerabilities

### 14.4.1 Freshwater resources

Freshwater resources will be affected by climate change across Canada and the U.S., but the nature of the vulnerabilities varies from region to region (NAST, 2001; Environment Canada, 2004; Lemmen and Warren, 2004). In certain regions including the Colorado River, Columbia River and Ogallala Aquifer, surface and/or groundwater resources are intensively used for often competing agricultural, municipal, industrial and ecological needs, increasing potential vulnerability to future changes in timing and availability of water (see Box 14.2).

*Surface water*

Simulated annual water yield in basins varies by region, General Circulation Model (GCM) or Regional Climate Model (RCM) scenario (Stonefelt et al., 2000; Fontaine et al., 2001; Stone et al., 2001; Rosenberg et al., 2003; Jha et al., 2004; Shushama et al., 2006 ), and the resolution of the climate model (Stone et al., 2003). Higher evaporation related to warming tends to offset the effects of more precipitation, while magnifying the effects of less precipitation (Stonefelt et al., 2000; Fontaine et al., 2001).

Warming, and changes in the form, timing and amount of precipitation, will very likely lead to earlier melting and significant reductions in snowpack in the western mountains by the middle of the 21st century (high confidence) (Loukas et al., 2002; Leung and Qian, 2003; Miller et al., 2003; Mote et al., 2003; Hayhoe et al., 2004). In projections for mountain snowmelt-dominated watersheds, snowmelt runoff advances, winter and early spring flows increase (raising flooding potential), and summer flows decrease substantially (Kim et al., 2002; Loukas et al., 2002; Snyder et al., 2002; Leung and Qian, 2003; Miller et al., 2003; Mote et al., 2003; Christensen et al., 2004; Merritt et al., 2005). Over-allocated water systems of the western U.S. and Canada, such as the Columbia River, that rely on capturing snowmelt runoff, will be especially vulnerable (see Box 14.2).

Lower water levels in the Great Lakes are likely to influence many sectors, with multi-dimensional, interacting impacts (Figure 14.2) (high confidence). Many, but not all, assessments project lower net basin supplies and water levels for the Great Lakes – St. Lawrence Basin (Mortsch et al., 2000; Quinn and Lofgren, 2000; Lofgren et al., 2002; Croley, 2003). In addition

## Box 14.2. Climate change adds challenges to managing the Columbia River system

Current management of water in the Columbia River basin involves balancing complex, often competing, demands for hydropower, navigation, flood control, irrigation, municipal uses, and maintenance of several populations of threatened and endangered species (e.g., salmon). Current and projected needs for these uses over-commit existing supplies. Water management in the basin operates in a complex institutional setting, involving two sovereign nations (Columbia River Treaty, ratified in 1964), aboriginal populations with defined treaty rights ('Boldt decision' in U.S. *vs.* Washington in 1974), and numerous federal, state, provincial and local government agencies (Miles et al., 2000; Hamlet, 2003). Pollution (mainly non-point source) is an important issue in many tributaries. The first-in-time first-in-right provisions of western water law in the U.S. portion of the basin complicate management and reduce water available to junior water users (Gray, 1999; Scott et al., 2004). Complexities extend to different jurisdictional responsibilities when flows are high and when they are low, or when protected species are in tributaries, the main stem or ocean (Miles et al., 2000; Mote et al., 2003).

With climate change, projected annual Columbia River flow changes relatively little, but seasonal flows shift markedly toward larger winter and spring flows and smaller summer and autumn flows (Hamlet and Lettenmaier, 1999; Mote et al., 1999). These changes in flows will likely coincide with increased water demand, principally from regional growth but also induced by climate change. Loss of water availability in summer would exacerbate conflicts, already apparent in low-flow years, over water (Miles et al. 2000). Climate change is also projected to impact urban water supplies within the basin. For example, a 2°C warming projected for the 2040s would increase demand for water in Portland, Oregon by 5.7 million $m^3$/yr with an additional demand of 20.8 million $m^3$/yr due to population growth, while decreasing supply by 4.9 million $m^3$/yr (Mote et al., 2003). Long-lead climate forecasts are increasingly considered in the management of the river but in a limited way ( Hamlet et al., 2002; Lettenmaier and Hamlet, 2003; Gamble et al., 2004; Payne et al., 2004). Each of 43 sub-basins of the system has its own sub-basin management plan for fish and wildlife, none of which comprehensively addresses reduced summertime flows under climate change (ISRP/ISAB, 2004).

The challenges of managing water in the Columbia River basin will likely expand with climate change due to changes in snowpack and seasonal flows (Miles et al., 2000; Parson et al., 2001b; Cohen et al., 2003). The ability of managers to meet operating goals (reliability) will likely drop substantially under climate change (as projected by the HadCM2 and ECHAM4/OPYC3 AOGCMs under the IPCC IS92a emissions scenario for the 2020s and 2090s) (Hamlet and Lettenmaier, 1999). Reliability losses are projected to reach 25% by the end of the 21st century (Mote et al., 1999) and interact with operational rule requirements. For example, 'fish-first' rules would reduce firm power reliability by 10% under present climate and 17% in years during the warm phase of the Pacific Decadal Oscillation. Adaptive measures have the potential to moderate the impact of the decrease in April snowpack, but lead to 10 to 20% losses of firm hydropower and lower than current summer flows for fish (Payne et al., 2004). Integration of climate change adaptation into regional planning processes is in the early stages of development (Cohen et al., 2006).

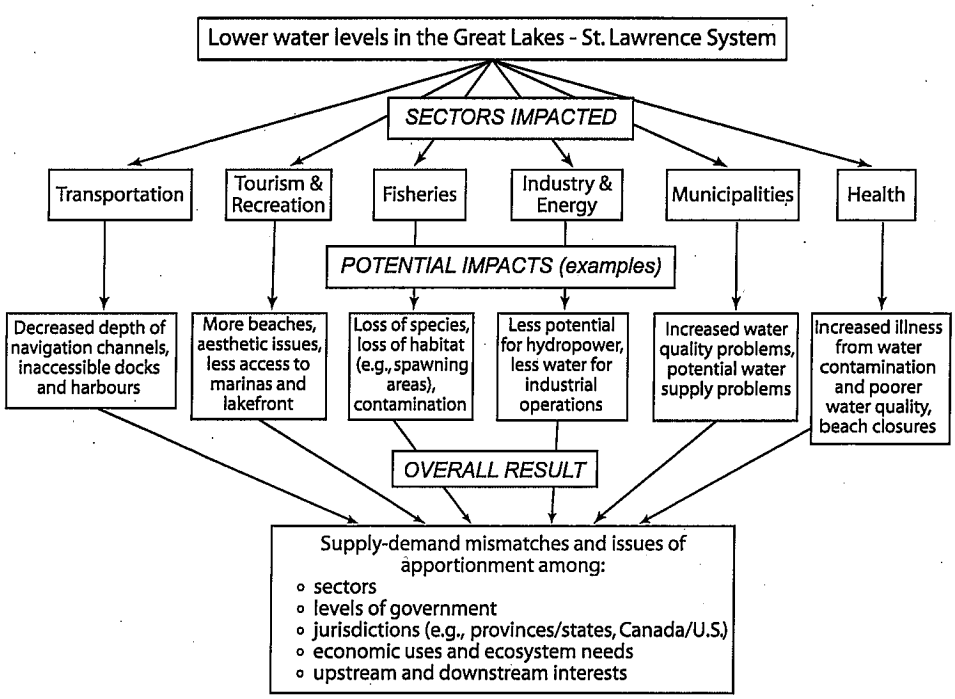


**Figure 14.2.** *Interconnected impacts of lower water levels in the Great Lakes - St Lawrence system (modified from Lemmen and Warren, 2004).*

to differences due to climate scenarios, uncertainties include atmosphere-lake interactions (Wetherald and Manabe, 2002; Kutzbach et al., 2005). Adapting infrastructure and dredging to cope with altered water levels would entail a range of costs (Changnon, 1993; Schwartz et al., 2004b). Adaptations sufficient to maintain commercial navigation on the St. Lawrence River could range from minimal adjustments to costly, extensive structural changes (St. Lawrence River-Lake Ontario Plan of Study Team, 1999; D'Arcy et al., 2005). There have been controversies in the Great Lakes region over diversions of water, particularly at Chicago, to address water quality, navigation, water demand and drought mitigation outside the region. Climate change will exacerbate these issues and create new challenges for bi-national co-operation (very high confidence) (Changnon and Glantz, 1996; Koshida et al., 2005).

*Groundwater*

With climate change, availability of groundwater is likely to be influenced by withdrawals (reflecting development, demand and availability of other sources) and recharge (determined by temperature, timing and amount of precipitation, and surface water interactions) (medium confidence) (Rivera et al., 2004). Simulated annual groundwater base flows and aquifer levels respond to temperature, precipitation and pumping – decreasing in scenarios that are drier or have higher pumping and increasing in a wetter scenario. In some cases there are base flow shifts - increasing in winter and decreasing in spring and early summer (Kirshen, 2002; Croley and Luukkonen, 2003; Piggott et al., 2003). For aquifers in alluvial valleys of south-central British Columbia, temperature and precipitation scenarios have less impact on groundwater recharge and levels than do projected changes in river stage[7] (Allen et al., 2004a,b).

Heavily utilised groundwater-based systems in the southwest U.S. are likely to experience additional stress from climate change that leads to decreased recharge (high confidence). Simulations of the Edwards aquifer in Texas under average recharge project lower or ceased flows from springs, water shortages, and considerable negative environmental impacts (Loáiciga, 2000; Loáiciga et al., 2000). Regional welfare losses associated with projected flow reductions (10 to 24%) range from US$2.2 million to 6.8 million/yr, with decreased net agricultural income as a consequence of water allocation shifting to municipal and industrial uses (Chen et al., 2001). In the Ogallala aquifer region, projected natural groundwater recharge decreases more than 20% in all simulations with warming of 2.5°C or greater (based on outputs from the GISS, UKTR and BMRC AOGCMs, with three atmospheric concentrations of $CO_2$: 365, 560 and 750 ppm) (Rosenberg et al., 1999).

*Water quality*

Simulated future surface and bottom water temperatures of lakes, reservoirs, rivers, and estuaries throughout North America consistently increase from 2 to 7°C (based on 2×$CO_2$ and IS92a scenarios) (Fang and Stefan, 1999; Hostetler and Small, 1999; Nicholls, 1999; Stefan and Fang, 1999; Lehman, 2002; Gooseff et al., 2005), with summer surface temperatures exceeding 30°C in Midwestern and southern lakes and reservoirs (Hostetler and Small, 1999). Warming is likely to extend and intensify summer thermal stratification, contributing to oxygen depletion. A shorter ice-cover period in shallow northern lakes could reduce winter fish kills caused by low oxygen (Fang and Stefan, 1999; Stefan and Fang, 1999; Lehman, 2002). Higher stream temperatures affect fish access, survival and spawning (e.g., west coast salmon) (Morrison et al., 2002).

Climate change is likely to make it more difficult to achieve existing water quality goals (high confidence). For the Midwest, simulated low flows used to develop pollutant discharge limits (Total Maximum Daily Loads) decrease over 60% with a 25% decrease in mean precipitation, reaching up to 100% with the incorporation of irrigation demands (Eheart et al., 1999). Restoration of beneficial uses (e.g., to address habitat loss, eutrophication, beach closures) under the Great Lakes Water Quality agreement will likely be vulnerable to declines in water levels, warmer water temperatures, and more intense precipitation (Mortsch et al., 2003). Based on simulations, phosphorus remediation targets for the Bay of Quinte (Lake Ontario) and surrounding watershed could be compromised as 3 to 4°C warmer water temperatures contribute to 77 to 98% increases in summer phosphorus concentrations in the bay (Nicholls, 1999), and as changes in precipitation, streamflow and erosion lead to increases in average phosphorus concentrations in streams of 25 to 35% (Walker, 2001). Decreases in snow cover and more winter rain on bare soil are likely to lengthen the erosion season and enhance erosion, increasing the potential for water quality impacts in agricultural areas (Atkinson et al., 1999; Walker, 2001; Soil and Water Conservation Society, 2003). Soil management practices (e.g., crop residue, no-till) in the Cornbelt may not provide sufficient erosion protection against future intense precipitation and associated runoff (Hatfield and Pruger, 2004; Nearing et al., 2004).

### 14.4.2 Ecosystems

Several simulations (Cox et al., 2000; Berthelot et al., 2002; Fung et al., 2005) indicate that, over the 21st century, warming will lengthen growing seasons, sustaining forest carbon sinks in North America despite some decreased sink strength resulting from greater water limitations in western forests and higher respiration in the tropics (medium confidence). Impacts on ecosystem structure and function may be amplified by changes in extreme meteorological events and increased disturbance frequencies. Ecosystem disturbances, caused either by humans or by natural events, accelerate both loss of native species and invasion of exotics (Sala et al., 2000).

*Primary production*

At high latitudes, several models simulate increased NPP as a result of expansion of forests into the tundra and longer growing seasons (Berthelot et al., 2002). In the mid-latitudes, simulated changes in NPP are variable, depending on whether there is sufficient enhancement of precipitation to offset

[7] River stage: water height relative to a set point.

increased evapotranspiration in a warmer climate (Bachelet et al., 2001; Berthelot et al., 2002; Gerber et al., 2004; Woodward and Lomas, 2004). Bachelet et al. (2001) project the areal extent of drought-limited ecosystems to increase by 11%/°C warming in the continental U.S. By the end of the 21st century, ecosystems in the north-east and south-east U.S. will likely become carbon sources, while the western U.S. remains a carbon sink (Bachelet et al., 2004).

Overall forest growth in North America will likely increase modestly (10-20%) as a result of extended growing seasons and elevated $CO_2$ over the next century (Morgan et al., 2001), but with important spatial and temporal variations (medium confidence). Growth of white spruce in Québec will be enhanced by a 1°C temperature increase but depressed with a 4°C increase (Andalo et al., 2005). A 2°C temperature increase in the Olympic Mountains (U.S.) would cause dominant tree species to shift upward in elevation by 300 to 600m, causing temperate species to replace sub-alpine species over 300 to 500 years (Zolbrod and Peterson, 1999). For widespread species such as lodgepole pine, a 3°C temperature increase would increase growth in the northern part of its range, decrease growth in the middle, and decimate southern forests (Rehfeldt et al., 2001).

*Population and community dynamics*

For many amphibians, whose production of eggs and migration to breeding ponds is intimately tied to temperature and moisture, mismatches between breeding phenology and pond drying can lead to reproductive failure (Beebee, 1995). Differential responses among species in arrival or persistence in ponds will likely lead to changes in community composition and nutrient flow in ponds (Wilbur, 1997). Changes in plant species composition in response to climate change can facilitate other disturbances, including fire (Smith et al., 2000) and biological invasion (Zavaleta and Hulvey, 2004). Bioclimate modelling based on output from five GCMs suggests that, over the next century, vertebrate and tree species richness will decrease in most parts of the conterminous U.S., even though long-term trends (over millennia) ultimately favour increased richness in some taxa and locations (Currie, 2001). Based on relationships between habitat area and biodiversity, 15 to 37% of plant and animal species in a global sample are likely to be 'committed to extinction' by 2050, although actual extinctions will be strongly influenced by human forces and could take centuries (Thomas et al., 2004).

### 14.4.3 Coastal regions

Added stress from rapid coastal development, including an additional 25 million people in the coastal U.S. over the next 25 years, will reduce the effectiveness of natural protective features, leading to impaired resilience. As property values and investment continue to rise, coastal vulnerability tends to increase on a broad scale (Pielke Jr. and Landsea, 1999; Heinz Center, 2000), with a sensitivity that depends on the commitment to and flexibility of adaptation measures. Disproportionate impacts due to socio-economic status are likely to be exacerbated by rising sea levels and storm severity (Wu et al., 2002; Kleinosky et al., 2006).

Sea-level rise has accelerated in eastern North America since the late 19th century (Donnelly et al., 2004) and further acceleration is expected (high confidence). For The IPCC Special Report on Emissions Scenarios (SRES, Nakićenović and Swart, 2000) scenario A1B, global mean sea level is projected to rise by 0.35 ± 0.12 m from the 1980 to 1999 period to the 2090 to 2099 period (Meehl et al., 2007: Section 10.6.5). Spatial variability of sea-level rise has become better defined since the TAR (Church et al., 2004) and the ensemble mean for A1B shows values close to the global mean along most North American coasts, with slightly higher rates in eastern Canada and western Alaska, and stronger positive anomalies in the Arctic (Meehl et al., 2007: Figure 10.32). Vertical land motion will decrease (uplift) or increase (subsidence) the relative sea-level rise at any site (Douglas and Peltier, 2002).

Superimposed on accelerated sea-level rise, the present storm and wave climatology and storm-surge frequency distributions lead to forecasts of more severe coastal flooding and erosion hazards. The water-level probability distribution is shifted upward, giving higher potential flood levels and more frequent flooding at levels rarely experienced today (very high confidence) (Zhang et al., 2000; Forbes et al., 2004). If coastal systems, including sediment supply, remain otherwise unchanged, higher sea levels are likely to be correlated with accelerated coastal erosion (Hansom, 2001; Cowell et al., 2003).

Up to 21% of the remaining coastal wetlands in the U.S. mid-Atlantic region are potentially at risk of inundation between 2000 and 2100 (IS92a emissions scenario) (Najjar et al., 2000). Rates of coastal wetland loss, in Chesapeake Bay and elsewhere (Kennish, 2002), will increase with accelerated sea-level rise, in part due to 'coastal squeeze' (high confidence). Salt-marsh biodiversity is likely to be diminished in north-eastern marshes through expansion of cordgrass (*Spartina alterniflora*) at the expense of high-marsh species (Donnelly and Bertness, 2001). Many salt marshes in less developed areas have some potential to keep pace with sea-level rise (to some limit) through vertical accretion (Morris et al., 2002; Chmura et al., 2003; Chmura and Hung, 2004). Where rapid subsidence increases rates of relative sea-level rise, however, as in the Mississippi Delta, even heavy sediment loads cannot compensate for inundation losses (Rybczyk and Cahoon, 2002).

Potentially more intense storms and possible changes in El Niño (Meehl et al., 2007: Sections 10.3.5.4 and 10.3.6.3) are likely to result in more coastal instability (medium confidence) (see Section 14.3.1) (Scavia et al., 2002; Forbes et al., 2004; Emanuel, 2005). Damage costs from coastal storm events (storm surge, waves, wind, ice encroachment) and other factors (such as freeze-thaw) have increased substantially in recent decades (Zhang et al., 2000; Bernatchez and Dubois, 2004) and are expected to continue rising (high confidence). Higher sea levels in combination with storm surges will cause widespread problems for transportation along the Gulf and Atlantic coasts (Titus, 2002). More winters with reduced sea ice in the Gulf of St. Lawrence, resulting in more open water during the winter storm season, will lead to an increase in the average number of storm-wave events per year, further accelerating coastal erosion (medium confidence) (Forbes et al., 2004).

### 14.4.4 Agriculture, forestry and fisheries

*Agriculture*

Research since the TAR supports the conclusion that moderate climate change will likely increase yields of North American rain-fed agriculture, but with smaller increases and more spatial variability than in earlier estimates (high confidence) (Reilly, 2002). Most studies project likely climate-related yield increases of 5 to 20% over the first decades of the century, with the overall positive effects of climate persisting through much or all of the 21st century. This pattern emerges from recent assessments for corn, rice, sorghum, soybean, wheat, common forages, cotton and some fruits (Adams et al., 2003; Polsky et al., 2003; Rosenberg et al., 2003; Tsvetsinskaya et al., 2003; Antle et al., 2004; Thomson et al., 2005b), including irrigated grains (Thomson et al., 2005b). Increased climate sensitivity is anticipated in the south-eastern U.S. and in the U.S. Cornbelt (Carbone et al., 2003), but not in the Great Plains (Mearns et al., 2003). Crops that are currently near climate thresholds (e.g., wine grapes in California) are likely to suffer decreases in yields, quality, or both, with even modest warming (medium confidence) (Hayhoe et al., 2004; White et al., 2006).

Recent integrated assessment model studies explored the interacting impacts of climate and economic factors on agriculture, water resources and biome boundaries in the conterminous U.S. (Edmonds and Rosenberg, 2005; Izaurralde et al., 2005; Rosenberg and Edmonds, 2005; Sands and Edmonds, 2005; Smith et al., 2005; Thomson et al., 2005a,b,c,d), concluding that scenarios with decreased precipitation create important challenges, restricting the availability of water for irrigation and at the same time increasing water demand for irrigated agriculture and urban and ecological uses.

The critical importance of specific agro-climatic events (e.g., last frost) introduces uncertainty in future projections (Mearns et al., 2003), as does continued debate about the $CO_2$ sensitivity of crop growth (Long et al., 2005). Climate change is expected to improve the climate for fruit production in the Great Lakes region and eastern Canada but with risks of early season frost and damaging winter thaws (Bélanger et al., 2002; Winkler et al., 2002). For U.S. soybean yield, adjusting the planting date can reduce the negative effects of late season heat stress and can more than compensate for direct effects of climate change (Southworth et al., 2002).

Vulnerability of North American agriculture to climatic change is multi-dimensional and is determined by interactions among pre-existing conditions, indirect stresses stemming from climate change (e.g., changes in pest competition, water availability), and the sector's capacity to cope with multiple, interacting factors, including economic competition from other regions as well as advances in crop cultivars and farm management (Parson et al., 2003). Water access is the major factor limiting agriculture in south-east Arizona, but farmers in the region perceive that technologies and adaptations such as crop insurance have recently decreased vulnerability (Vasquez-Leon et al., 2002). Areas with marginal financial and resource endowments (e.g., the U.S. northern plains) are especially vulnerable to climate change (Antle et al., 2004). Unsustainable land-use practices will tend to increase the vulnerability of agriculture in the U.S. Great Plains to climate change (Polsky and Easterling, 2001).

*Forestry*

Across North America, impacts of climate change on commercial forestry potential are likely to be sensitive to changes in disturbances (Dale et al., 2001) from insects (Gan, 2004), diseases (Woods et al., 2005) and wildfires (high confidence) (see Box 14.1). Warmer summer temperatures are projected to extend the annual window of high fire ignition risk by 10-30%, and could result in increased area burned of 74-118% in Canada by 2100 (Brown et al., 2004; Flannigan et al., 2004). In the absence of dramatic increases in disturbance, effects of climate change on the potential for commercial harvest in one study for the 2040s ranged from mixed for a low emissions scenario (the EPPA LLH emissions scenario) to positive for a high emissions scenario (the EPPA HHL emissions scenario) (Perez-Garcia et al., 2002). Scenarios with increased harvests tend to lead to lower prices and, as a consequence, reduced harvests, especially in Canada (Perez-Garcia et al., 2002; Sohngen and Sedjo, 2005). The tendency for North American producers to suffer losses increases if climate change is accompanied by increased disturbance, with simulated losses averaging US$1 billion to 2 billion/yr over the 21st century (Sohngen and Sedjo, 2005). Increased tropospheric ozone could cause further decreases in tree growth (Karnosky et al., 2005). Risks of losses from Southern pine beetle likely depend on the seasonality of warming, with winter and spring warming leading to the greatest damage (Gan, 2004).

Warmer winters with more sporadic freezing and thawing are likely to increase erosion and landslides on forest roads, and reduce access for winter harvesting (Spittlehouse and Stewart, 2003).

*Freshwater fisheries*

Cold-water fisheries will likely be negatively affected by climate change; warm-water fisheries will generally gain; and the results for cool-water fisheries will be mixed, with gains in the northern and losses in the southern portions of ranges (high confidence) (Stefan et al., 2001; Rahel, 2002; Shuter et al., 2002; Mohseni et al., 2003; Fang et al., 2004). Salmonids, which prefer cold, clear water, are likely to experience the most negative impacts (Gallagher and Wood, 2003). Arctic freshwaters will likely be most affected, as they will experience the greatest warming (Wrona et al., 2005). Many warm-water and cool-water species will shift their ranges northward or to higher altitudes (Clark et al., 2001; Mohseni et al., 2003). In the continental U.S., cold-water species will likely disappear from all but the deeper lakes, cool-water species will be lost mainly from shallow lakes, and warm-water species will thrive except in the far south, where temperatures in shallow lakes will exceed survival thresholds (see Section 14.4.1) (Stefan et al., 2001). Species already listed as threatened will face increased risk of extinction (Chu et al., 2005), with pressures from climate exacerbated by the expansion of predatory species like smallmouth bass (Jackson and Mandrak, 2002). In Lake Erie, larval recruitment of river-spawning walleye will depend on temperature and flow changes, but lake-spawning stocks will likely decline due to the effects of

warming and lower lake levels (Jones et al., 2006). Thermal habitat suitable for yellow perch will expand, while that for lake trout will contract (Jansen and Hesslein, 2004). While temperature increases may favour warm-water fishes like smallmouth bass, changes in water supply and flow regimes seem likely to have negative effects (Peterson and Kwak, 1999).

### 14.4.5 Human health

Risks from climate change to human health will be strongly modulated by changes in health care infrastructure, technology, and accessibility as well as ageing of the population, and patterns of immigration and/or emigration (UNPD, 2005). Across North America, the population over the age of 65 will increase slowly to 2010, and then grow dramatically as the Baby Boomers join the ranks of the elderly – the segment of the population most at risk of dying in heatwaves.

*Heatwaves and health*

Severe heatwaves, characterised by stagnant, warm air masses and consecutive nights with high minimum temperatures, will intensify in magnitude and duration over the portions of the U.S. and Canada where they already occur (high confidence) (Cheng et al., 2005). Late in the century, Chicago is projected to experience 25% more frequent heatwaves annually (using the PCM AOGCM with a business-as-usual emissions scenario, for the period 2080 to 2099) (Meehl and Tebaldi, 2004), and the projected number of heatwave days in Los Angeles increases from 12 to 44-95 (based on PCM and HadCM3 for the A1FI and B1 scenarios, for the 2070 to 2099 period) (Hayhoe et al., 2004).

*Air pollution*

Surface ozone concentration may increase with a warmer climate. Ozone damages lung tissue, causing particular problems for people with asthma and other lung diseases. Even modest exposure to ozone may encourage the development of asthma in children (McConnell et al., 2002; Gent et al., 2003). Ozone and non-volatile secondary particulate matter generally increase at higher temperatures, due to increased gas-phase reaction rates (Aw and Kleeman, 2002). Many species of trees emit volatile organic compounds (VOC) such as isoprene, a precursor of ozone (Lerdau and Keller, 1998), at rates that increase rapidly with temperature (Guenther, 2002).

For the 2050s, daily average ozone levels are projected to increase by 3.7 ppb across the eastern U.S. (based on the GISS/MM5 AOGCM and the SRES A2 emissions scenario), with the cities most polluted today experiencing the greatest increase in ozone pollution (Hogrefe et al., 2004). One-hour maximum ozone follows a similar pattern, with the number of summer days exceeding the 8-hour regulatory U.S. standard projected to increase by 68% (Bell et al., 2007). Assuming constant population and dose-response characteristics, ozone-related deaths from climate change increase by approximately 5% from the 1990s to the 2050s (Knowlton et al., 2004; Bell et al., 2007). The large potential population exposed to outdoor air pollution translates this small relative risk into a substantial attributable health risk.

*Pollen*

Pollen, another air contaminant, is likely to increase with elevated temperature and atmospheric $CO_2$ concentrations. A doubling of the atmospheric $CO_2$ concentration stimulated ragweed-pollen production by over 50% (Wayne et al., 2002). Ragweed grew faster, flowered earlier and produced significantly greater above-ground biomass and pollen at urban than at rural locations (Ziska et al., 2003).

*Lyme disease*

The northern boundary of tick-borne Lyme disease is limited by cold temperature effects on the tick, *Ixodes scapularis*. The northern range limit for this tick could shift north by 200 km by the 2020s, and 1000 km by the 2080s (based on projections from the CGCM2 and HadCM3 AOGCMs under the SRES A2 emissions scenario) (Ogden et al., 2006).

### 14.4.6 Human settlements

*Economic base*

The economies of resource-dependent communities and indigenous communities in North America are particularly sensitive to climate change, with likely winners and losers controlled by impacts on important local resources (see Sections 14.4.1, 14.4.4 and 14.4.7). Residents of northern Canada and Alaska are likely to experience the most disruptive impacts of climate change, including shifts in the range or abundance of wild species crucial to the livelihoods and well-being of indigenous peoples (high confidence) (see Chapter 15 Sections 15.4.2.4 and 15.5) (Houser et al., 2001; NAST, 2001; Parson et al., 2001a; ACIA, 2005).

*Infrastructure, climate trends and extreme events*

Many of the impacts of climate change on infrastructure in North America depend on future changes in variability of precipitation and extreme events, which are likely to increase but with substantial uncertainty (Meehl et al., 2007: Section 10.5.1; Christensen et al., 2007: Section 11.5.3). Infrastructure in Alaska and northern Canada is known to be vulnerable to warming. Among the most sensitive areas are those affected by coastal erosion and thawing of ice-rich permafrost (see Chapter 15 Section 15.7.1) (NAST, 2001; Arctic Research Commission, 2003; ACIA, 2005). Building, designing, and maintaining foundations, pipelines and road and railway embankments will become more expensive due to permafrost thaw (ACIA, 2005). Examples where infrastructure is projected to be at 'moderate to high hazard' in the mid-21st century include Shishmaref, Nome and Barrow in Alaska, Tuktoyaktuk in the Northwest Territories, the Dalton Highway in Alaska, the Dempster Highway in the Yukon, airfields in the Hudson Bay region, and the Alaska Railroad (based on the ECHAM1-A, GFDL89 and UKTR climate models) (Nelson et al., 2002; Instanes et al., 2005).

Since the TAR, a few studies have projected increasing vulnerability of infrastructure to extreme weather related to climate warming unless adaptation is effective (high confidence). Examples include the New York Metropolitan Region (Rosenzweig and Solecki, 2001) (see Box 14.3), the mid-Atlantic Region (Fisher, 2000; Barron, 2001; Wu et al.,

## Box 14.3. North American cities integrate impacts across multiple scales and sectors

Impacts of climate change in the metropolitan regions of North America will be similar in many respects. Los Angeles, New York and Vancouver are used to illustrate some of the affected sectors, including infrastructure, energy and water supply. Adaptation will need to be multi-decadal and multi-dimensional, and is already beginning (see Section 14.5).

*Infrastructure*

Since most large North American cities are on tidewater, rivers or both, effects of climate change will likely include sea-level rise (SLR) and/or riverine flooding. The largest impacts are expected when SLR, heavy river flows, high tides and storms coincide (California Regional Assessment Group, 2002). In New York, flooding from the combination of SLR and storm surge could be several metres deep (Gornitz and Couch, 2001; Gornitz et al., 2001). By the 2090s under a strong warming scenario (the CGCM climate model with the CCGG emissions scenario), today's 100-year flood level could have a return period of 3 to 4 years, and today's 500-year flood could be a 1-in-50-year event, putting much of the region's infrastructure at increased risk (Jacob et al., 2001; Major and Goldberg, 2001).

*Energy supply and demand*

Climate change will likely lead to substantial increases in electricity demand for summer cooling in most North American cities (see Section 14.4.8). This creates a number of conflicts, both locally and at a distance. In southern California, additional summer electricity demand will intensify inherent conflicts between state-wide hydropower and flood-control objectives (California Regional Assessment Group, 2002). Operating the Columbia River dams that supply 90% of Vancouver's power would be complicated by lower flows and environmental requirements (see Box 14.2). In New York, supplying summer electricity demand could increase air pollutant levels (e.g., ozone) (Hill and Goldberg, 2001; Kinney et al., 2001; Knowlton et al., 2004) and health impacts could be further exacerbated by climate change interacting with urban heat island effects (Rosenzweig et al., 2005). Unreliable electric power, as in minority neighbourhoods during the New York heatwave of 1999, can amplify concerns about health and environmental justice (Wilgoren and Roane, 1999).

*Water supply systems*

North American city water supply systems often draw water from considerable distances, so climate impacts need not be local to affect cities. By the 2020s, 41% of the supply to southern California is likely to be vulnerable to warming from loss of Sierra Nevada and Colorado River basin snowpack (see Section 14.4.1). Similarly, less mountain snowpack and summer runoff could require that Vancouver undertakes additional conservation and water restrictions, expands reservoirs, and develops additional water sources (Schertzer et al., 2004). The New York area will likely experience greater water supply variability (Solecki and Rosenzweig, 2007). The New York system can likely accommodate this, but the region's smaller systems may be vulnerable, leading to a need for enhanced regional water distribution protocols (Hansler and Major, 1999).

*Adaptation*

Many cities in North America have initiated 'no regrets' actions based on historical experience. In the Los Angeles area, incentive and information programmes of local water districts encourage water conservation (MWD, 2005). A population increase of over 35% (nearly one million people) since 1970 has increased water use in Los Angeles by only 7% (California Regional Assessment Group, 2002). New York has reduced total water consumption by 27% and per capita consumption by 34% since the early 1980s (City of New York, 2005). Vancouver's 'CitiesPLUS' 100-year plan will upgrade the drainage system by connecting natural areas and waterways, developing locally resilient, smaller systems, and upgrading key sections of pipe during routine maintenance (Denault et al., 2002).

2002; Rygel et al., 2006) and the urban transportation network of the Boston metropolitan area (Suarez et al., 2005). For Boston, projections of a gradual increase (0.31%/yr) in the probability of the 100-year storm surge, as well as sea-level rise of 3 mm/yr, leads to urban riverine and coastal flooding (based on the CGCM1 climate model), but the projected economic damages do not justify the cost of adapting the transportation infrastructure to climate change.

Less reliable supplies of water are likely to create challenges for managing urban water systems as well as for industries that depend on large volumes of water (see Sections 14.2.1, 14.4.1). U.S. water managers anticipate local, regional or state-wide water shortages during the next ten years (GAO, 2003). Threats to reliable supply are complicated by the high population growth rates in western states where many water resources are at or approaching full utilisation (GAO, 2003) (see Section 14.4.1). Potential increases in heavy precipitation, with expanding impervious surfaces, could increase urban flood risks and create additional design challenges and costs for stormwater management (Kije Sipi Ltd., 2001).

### 14.4.7 Tourism and recreation

Although coastal zones are among the most important recreation resources in North America, the vulnerability of key tourism areas to sea-level rise has not been comprehensively assessed. The cost to protect Florida beaches from a 0.5 m rise in sea level, with sand replenishment, was estimated at US$1.7 billion to 8.8 billion (EPA, 1999).

Nature-based tourism is a major market segment, with over 900 million visitor-days in national/provincial/state parks in 2001. Visits to Canada's national parks system are projected to increase by 9 to 25% (2050s) and 10 to 40% (2080s) as a result of a lengthened warm-weather tourism season (based on the PCM GCM and the SRES B2 emissions scenario, and the CCSR GCM with A1) (Jones and Scott, 2006). This would have economic benefits for park agencies and nearby communities, but could exacerbate visitor-related ecological pressures in some parks. Climate-induced environmental changes (e.g., loss of glaciers, altered biodiversity, fire- or insect-impacted forests) would also affect park tourism, although uncertainty is higher regarding the regional specifics and magnitude of these impacts (Richardson and Loomis, 2004; Scott et al., 2007a).

Early studies of the impact of climate change on the ski industry did not account for snowmaking, which substantially lowers the vulnerability of ski areas in eastern North America for modest (B2 emissions scenario) but not severe (A1) warming (based on 5 GCMs for the 2050s) (Scott et al., 2003; Scott et al., 2007b). Without snowmaking, the ski season in western North America will likely shorten substantially, with projected losses of 3 to 6 weeks (by the 2050s) and 7 to 15 weeks (2080s) in the Sierra Nevada of California (based on PCM and HadCM3 GCMs for the B1 and A1FI scenarios), and 7 to 10 weeks at lower elevations and 2 to 14 weeks at higher elevations at Banff, Alberta (based on the PCM GCM with the B2 emissions scenario, and the CCSR GCM with A1, for the 2050s) (Hayhoe et al., 2004; Scott and Jones, 2005). With advanced snowmaking, the ski season in Banff shortens at low but not at high altitudes. The North American snowmobiling industry (valued at US$27 billion) (ISMA, 2006) is more vulnerable to climate change because it relies on natural snowfall. By the 2050s, a reliable snowmobile season disappears from most regions of eastern North America that currently have developed trail networks (based on the CGCM1 and HadCM3 GCMs with IS92a emissions, the PCM GCM with B2 emissions and the CCSR GCM with A1 emissions) (Scott, 2006; Scott and Jones, 2006).

### 14.4.8 Energy, industry and transportation

*Energy demand*

Recent North American studies generally confirm earlier work showing a small net change (increase or decrease, depending on methods, scenarios and location) in the net demand for energy in buildings but a significant increase in demand for electricity for space cooling, with further increases caused by additional market penetration of air conditioning (high confidence) (Sailor and Muñoz, 1997; Mendelsohn and Schlesinger, 1999; Morrison and Mendelsohn, 1999; Mendelsohn, 2001; Sailor, 2001; Sailor and Pavlova, 2003; Scott et al., 2005; Hadley et al., 2006). Ruth and Amato (2002) projected a 6.6% decline in annual heating fuel consumption for Massachusetts in 2020 (linked to an 8.7% decrease in heating degree-days) and a 1.9% increase in summer electricity consumption (12% increase in annual cooling degree-days). In Québec, net energy demand for heating and air conditioning across all sectors could fall by 9.4% of 2001 levels by 2100 (based on the CGCM1 GCM and the IS92a emissions scenario), with residential heating falling by 10 to 15% and air conditioning increasing two- to four-fold. Peak electricity demand is likely to decline in the winter peaking system of Quebec, while summer peak demand is likely to increase 7 to 17% in the New York metropolitan region (Ouranos, 2004).

*Energy supply*

Since the TAR, there have been regional but not national-level assessments of the effects of climate change on future hydropower resources in North America. For a 2 to 3°C warming in the Columbia River Basin and British Columbia Hydro service areas, the hydroelectric supply under worst-case water conditions for winter peak demand will likely increase (high confidence). However, generating power in summer will likely conflict with summer instream flow targets and salmon restoration goals established under the Endangered Species Act (Payne et al., 2004). This conclusion is supported by accumulating evidence of a changing hydrologic regime in the western U.S. and Canada (see Sections 14.2.1, 14.4.1, Box 14.2). Similarly, Colorado River hydropower yields will likely decrease significantly (medium confidence) (Christensen et al., 2004), as will Great Lakes hydropower (Moulton and Cuthbert, 2000; Lofgren et al., 2002; Mirza, 2004). James Bay hydropower will likely increase (Mercier, 1998; Filion, 2000). Lower Great Lake water levels could lead to large economic losses (Canadian $437 million to 660 million/yr), with increased water levels leading to small gains (Canadian $28 million to 42 million/yr) (Buttle et al., 2004; Ouranos, 2004). Northern Québec hydropower production would likely benefit from greater precipitation and more open-water conditions, but hydro plants in southern Québec would likely be affected by lower water levels. Consequences of changes in seasonal distribution of flows and in the timing of ice formation are uncertain (Ouranos, 2004).

Wind and solar resources are about as likely as not to increase (medium confidence). The viability of wind resources depends on both wind speed and reliability. Studies to date project wind resources that are unchanged by climate change (based on the HadGCM2 CGSa4 experiment) or reduced by 0 to 40% (based on CGCM1 and the SRES A1 scenario, and HadCM2 and RegCM2 and a 1%/yr $CO_2$ increase) (Segal et al., 2001; Breslow and Sailor, 2002). Future changes in cloudiness could slightly increase the potential for solar energy in North America south of 60°N (using many models, the A1B scenario and for 2080 to 2099 *vs.* 1980 to 1999) (Meehl et al., 2007: Figure 10.10). However, Pan et al. (2004) projected the opposite: that increased cloudiness will likely decrease the potential output of photovoltaics by 0 to 20% (based on HadCM2 and RegCM2 and a 1%/yr $CO_2$ increase for the 2040s).

Bioenergy potential is climate-sensitive through direct impacts on crop growth and availability of irrigation water. Bioenergy crops are projected to compete successfully for agricultural acreage at a price of US$33/Mg, or about US$1.83/$10^9$ joules (Walsh et al., 2003). Warming and precipitation increases are expected to allow the bioenergy crop switchgrass to compete effectively with traditional crops in the central U.S. (based on RegCM2 and a $2\times CO_2$ scenario) (Brown et al., 2000).

*Construction*

As projected in the TAR, the construction season in Canada and the northern U.S. will likely lengthen with warming (see Section 14.3.1 and Christensen et al., 2007 Section 11.5.3). In permafrost areas in Canada and Alaska, increasing depth of the 'active layer' or loss of permafrost can lead to substantial decreases in soil strength (ACIA, 2004). In areas currently underlain by permafrost, construction methods are likely to require changes (Cole et al., 1998), potentially increasing construction and maintenance costs (high confidence) (see Chapter 15 Section 15.7.1) (ACIA, 2005).

*Transportation*

Warmer or less snowy winters will likely reduce delays, improve ground and air transportation reliability, and decrease the need for winter road maintenance (Pisano et al., 2002). More intense winter storms could, however, increase risks for traveller safety (Andrey and Mills, 2003) and require increased snow removal. Continuation of the declining fog trend in at least some parts of North America (Muraca et al., 2001; Hanesiak and Wang, 2005) should benefit transport. Improvements in technology and information systems will likely modulate vulnerability to climate change (Andrey and Mills, 2004).

Negative impacts of climate change on transportation will very likely result from coastal and riverine flooding and landslides (Burkett, 2002). Although offset to some degree by fewer ice threats to navigation, reduced water depth in the Great Lakes would lead to the need for 'light loading' and, hence, adverse economic impacts (see Section 14.4.1) (du Vair et al., 2002; Quinn, 2002; Millerd, 2005). Adaptive measures, such as deepening channels for navigation, would need to address both institutional and environmental challenges (Lemmen and Warren, 2004).

Warming will likely adversely affect infrastructure for surface transport at high northern latitudes (Nelson et al., 2002). Permafrost degradation reduces surface load-bearing capacity and potentially triggers landslides (Smith and Levasseur, 2002; Beaulac and Doré, 2005). While the season for transport by barge is likely to be extended, the season for ice roads will likely be compressed (Lonergan et al., 1993; Lemmen and Warren, 2004; Welch, 2006). Other types of roads are likely to incur costly improvements in design and construction (Stiger, 2001; McBeath, 2003; Greening, 2004) (see Chapter 15 Section 15.7.1).

An increase in the frequency, intensity or duration of heat spells could cause railroad track to buckle or kink (Rosetti, 2002), and affect roads through softening and traffic-related rutting (Zimmerman, 2002). Some problems associated with warming can be ameliorated with altered road design, construction and management, including changes in the asphalt mix and the timing of spring load restrictions (Clayton et al., 2005; Mills et al., 2006).

### 14.4.9 Interacting impacts

Impacts of climate change on North America will not occur in isolation, but in the context of technological, economic (Nakićenović and Swart, 2000; Edmonds, 2004), social (Lebel, 2004; Reid et al., 2005) and ecological changes (Sala et al., 2000). In addition, challenges from climate change will not appear as isolated effects on a single sector, region, or group. They will occur in concert, creating the possibility of a suite of local, as well as long-distance, interactions, involving both impacts of climate change and other societal and ecosystem trends (NAST, 2001; Reid et al., 2005). In some cases, these interactions may reduce impacts or decrease vulnerability, but in others they may amplify impacts or increase vulnerability.

Effects of climate change on ecosystems do not occur in isolation. They co-occur with numerous other factors, including effects of land-use change (Foley et al., 2005), air pollution (Karnosky et al., 2005), wildfires (see Box 14.1), changing biodiversity (Chapin et al., 2000) and competition with invasives (Mooney et al., 2005). The strong dependence of ecosystem function on moisture balance (Baldocchi and Valentini, 2004), coupled with the greater uncertainty about future precipitation than about future temperature (Christensen et al., 2007: Section 11.5.3), further expands the range of possible futures for North American ecosystems.

People also experience climate change in a context that is strongly conditioned by changes in other sectors and their adaptive capacity. Interactions with changes in material wealth (Ikeme, 2003), the vitality of local communities (Hutton, 2001; Wall et al., 2005), the integrity of key infrastructure (Jacob et al., 2001), the status of emergency facilities and preparedness and planning (Murphy et al. 2005), the sophistication of the public health system (Kinney et al., 2001), and exposure to conflict (Barnett, 2003), all have the potential to either exacerbate or ameliorate vulnerability to climate change. Among the unexpected consequences of the population displacement caused by Hurricane Katrina in 2005 is the strikingly poorer health of storm evacuees, many of whom lost jobs, health insurance, and stable relationships with medical professionals (Columbia University Mailman School of Public Health, 2006).

Little of the literature reviewed in this chapter addresses interactions among sectors that are all impacted by climate change, especially in the context of other changes in economic activity, land use, human population, and changing personal and political priorities. Similarly, knowledge of the indirect impacts on North America of climate change in other geographical regions is very limited.

## 14.5 Adaptation: practices, options and constraints

The U.S. and Canada are developed economies with extensive infrastructure and mature institutions, with important regional and socio-economic variations (NAST, 2000; Lemmen and Warren, 2004). These capabilities have led to adaptation and coping strategies across a wide range of historic conditions, with

both successes and failures. Most studies on adaptive strategies consider implementation based on past experiences (Paavola and Adger, 2002). Examples of adaptation based on future projections are rare (Smit and Wall, 2003; Devon, 2005). Expanding beyond reactive adaptation to proactive, anticipatory adaptive strategies presents many challenges. Progress toward meeting these challenges is just beginning in North America.

### 14.5.1 Practices and options

Canada and the U.S. emphasise market-based economies. Governments often play a role implementing large-scale adaptive measures, and in providing information and incentives to support development of adaptive capacity by private decision makers (UNDP, 2001; Michel-Kerjan, 2006). In practice, this means that individuals, businesses and community leaders act on perceived self interest, based on their knowledge of adaptive options. Despite many examples of adaptive practices in North America, under-investment in adaptation is evident in the recent rapid increase in property damage due to climate extremes (Burton and Lim, 2005; Epstein and Mills, 2005) and illustrates the current adaptation deficit.

*Adaptation by individuals and private businesses*

Research on adaptive behaviour for coping with projected climate change is minimal, though several studies address adaptations to historic variation in the weather. About 70% of businesses face some weather risk. The impact of weather on businesses in the U.S. is an estimated US$200 billion/yr (Lettre, 2000). Climate change may also create business opportunities. For example, spending on storm-worthiness and construction of disaster-resilient homes (Koppe et al., 2004; Kovacs, 2005b; Kunreuther, 2006) increased substantially after the 2004 and 2005 Atlantic hurricanes, as did the use of catastrophe bonds (CERES, 2004; Byers et al., 2005; Dlugolecki, 2005; Guy Carpenter, 2006).

Businesses in Canada and the U.S. are investing in climate-relevant adaptations, though few of these appear to be based on projections of future climate change. For example:

- Insurance companies are introducing incentives for homeowners and businesses that invest in loss prevention strategies (Kim, 2004; Kovacs, 2005b).
- Insurance companies are investing in research to prevent future hazard damage to insured property, and to adjust pricing models (Munich Re., 2004; Mills and Lecomte, 2006).
- Ski resort operators are investing in lifts to reach higher altitudes and in snow-making equipment (Elsasser et al., 2003; Census Bureau, 2004; Scott, 2005; Jones and Scott, 2006; Scott et al., 2007a).
- With highly detailed information on weather conditions, farmers are adjusting crop and variety selection, irrigation strategies and pesticide application (Smit and Wall, 2003).
- The forest resources sector is investing in improved varieties, forest protection, forest regeneration, silvicultural management and forest operations (Loehle et al., 2002; Spittlehouse and Stewart, 2003).

*Adaptation by governments and communities*

Many North American adaptations to climate-related risks are implemented at the community level. These include efforts to minimise damage from heatwaves, droughts, floods, wildfires or tornados. These actions may entail land-use planning, building code enforcement, community education and investments in critical infrastructure (Burton et al., 2002; Multihazard Mitigation Council, 2005).

Flooding and drought present recurring challenges for many North American communities (Duguid, 2002). When the City of Peterborough, Canada, experienced two 100-year flood events within three years, it responded by flushing the drainage systems and replacing the trunk sewer systems to meet more extreme 5-year flood criteria (Hunt, 2005). Recent droughts in six major U.S. cities, including New York and Los Angeles, led to adaptive measures involving investments in water conservation systems and new water supply-distribution facilities (Changnon and Changnon, 2000). To cope with a 15% increase in heavy precipitation, Burlington and Ottawa, Ontario, employed both structural and non-structural measures, including directing downspouts to lawns to encourage infiltration and increasing depression and street detention storage (Waters et al., 2003).

Some large cities (e.g., New Orleans) and important infrastructure (e.g., the only highway and rail link between Nova Scotia and the rest of Canada) are located on or behind dykes that will provide progressively less protection unless raised on an ongoing basis. Some potential damages may be averted through redesigning structures, raising the grade, or relocating (Titus, 2002). Following the 1996 Saguenay flood and 1998 ice storm, the province of Québec modified the Civil Protection Act and now requires municipalities to develop comprehensive emergency management plans that include adaptation strategies (McBean and Henstra, 2003). More communities are expected to re-examine their hazard management systems following the catastrophic damage in New Orleans from Hurricane Katrina (Kunreuther et al., 2006).

Rapid development and population growth are occurring in many coastal areas that are sensitive to storm impacts (Moser, 2005). While past extreme events have motivated some aggressive adaptation measures (e.g., in Galveston, Texas) (Bixel and Turner, 2000), the passage of time, new residents, and high demand for waterfront property are pushing coastal development into vulnerable areas.

Climate change will likely increase risks of wildfire (see Box 14.1). FireWise and FireSmart are programmes promoting wildfire safety in the U.S. and Canada, respectively (FireSmart, 2005; FireWise, 2005). Individual homeowners and businesses can participate, but the greatest reduction in risk will occur in communities that take a comprehensive approach, managing forests with controlled burns and thinning, promoting or enforcing appropriate roofing materials, and maintaining defensible space around each building (McGee et al., 2000).

Public institutions are responsible for adapting their own legislation, programmes and practices to appropriately anticipate climate changes. The recent Québec provincial plan, for example, integrates climate change science into public policy. Public institutions can also use incentives to encourage or to

overcome disincentives to investment by private decision makers (Moser, 2006). Options, including tax assistance, loan guarantees and grants, can improve resilience to extremes and reduce government costs for disaster management (Moser, 2005). The U.S. National Flood Insurance Program is changing its policy to reduce the risk of multiple flood claims, which cost the programme more than US$200 million/yr (Howard, 2000). Households with two flood-related claims are now required to elevate their structure 2.5 cm above the 100-year flood level, or relocate. To complement this, a 5-year, US$1 billion programme to update and digitise flood maps was initiated in 2003 (FEMA, 2006). However, delays in implementing appropriate zoning can encourage accelerated, maladapted development in coastal communities and flood plains.

### 14.5.2 Mainstreaming adaptation

One of the greatest challenges in adapting North America to climate change is that individuals often resist and delay change (Bacal, 2000). Good decisions about adapting to climate change depend on relevant experience (Slovic, 2000), socio-economic factors (Conference Board of Canada, 2006), and political and institutional considerations (Yarnal et al., 2006; Dow et al., 2007). Adaptation is a complex concept (Smit et al., 2000; Dolan and Walker, 2006), that includes wealth and several other dimensions.

*Experience and knowledge*

The behaviour of people and systems in North America largely reflects historic climate experience (Schipper et al., 2003), which has been institutionalised through building codes, flood management infrastructure, water systems and a variety of other programmes. Canadian and U.S. citizens have invested in buildings, infrastructure, water and flood management systems designed for acceptable performance under historical conditions (Bruce, 1999; Co-operative Programme on Water and Climate, 2005; UMA Engineering, 2005; Dow et al., 2007). Decisions by community water managers (Rayner et al., 2005; Dow et al., 2007) and set-back regulations in coastal areas (Moser, 2005) also account for historic experience but rarely incorporate information about climate change or sea-level rise. In general, decision makers lack the tools and perspectives to integrate future climate, particularly events that exceed historic norms (UNDP, 2001).

Examples of adaptive behaviour influenced exclusively or predominantly by projections of climate change are largely absent from the literature, but some early steps toward planned adaptation have been taken by the engineering community, insurance companies, water managers, public health officials, forest managers and hydroelectric producers. Some initiatives integrate consideration of climate change into the environmental impact assessment process. Philadelphia, Toronto and a few other communities have introduced warning programmes to manage the health threat of heatwaves (Kalkstein, 2002). The introduction of Toronto's heat/health warning programme was influenced by both climate projections and fatalities from past heatwaves (Koppe et al., 2004; Ligeti, 2006).

Weather extremes can reveal a community's vulnerability or resilience (RMS, 2005a) and provide insights into potential adaptive responses to future events. Since the 1998 ice storm, Canada's two most populous provinces, Ontario and Québec, have strengthened emergency preparedness and response capacity. Included are comprehensive hazard-reduction measures and loss-prevention strategies to reduce vulnerability to extreme events. These strategies may include both public information programmes and long-term strategies to invest in safety infrastructure (McBean and Henstra, 2003). Adaptive behaviour is typically greater in the communities that recently experienced a natural disaster (Murphy et al., 2005). But the near absence of any personal preparedness following the 2003 blackout in eastern North America demonstrated that adaptive actions do not always follow significant emergencies (Murphy, 2004).

*Socio-economic factors*

Wealthier societies tend to have greater access to technology, information, developed infrastructure, and stable institutions (Easterling et al., 2004), which build capacity for individual and collective action to adapt to climate change. But average economic status is not a sufficient determinant of adaptive capacity (Moss et al., 2001). The poor and marginalised in Canada and the U.S. have historically been most at risk from weather shocks (Turner et al., 2003), with vulnerability directly related to income inequality (Yohe and Tol, 2002). Differences in individual capacity to cope with extreme weather were evident in New Orleans during and after Hurricane Katrina (Kunreuther et al., 2006), when the large majority of those requiring evacuation assistance were either poor or in groups with limited mobility, including elderly, hospitalised and disabled citizens (Murphy et al., 2005; Kumagi et al., 2006; Tierney, 2006).

*Political and institutional capacity for autonomous adaptation*

Public officials in Canada and the U.S. typically provide early and extensive assistance in emergencies. Nevertheless, emergency response systems in the U.S. and Canada are based on the philosophy that households and businesses should be capable of addressing their own basic needs for up to 72 hours after a disaster (Kovacs and Kunreuther, 2001). The residents' vulnerability depends on their own resources, plus those provided by public service organisations, private firms and others (Fischhoff, 2006). When a household is overwhelmed by an extreme event, household members often rely on friends, family and other social networks for physical and emotional support (Cutter et al., 2000; Enarson, 2002; Murphy, 2004). When a North American community responds to weather extremes, non-governmental organisations often coordinate support for community-based efforts (National Voluntary Organizations Active in Disaster, 2006).

An active dialogue among stakeholders and political institutions has the potential to clarify the opportunities for adaptation to changing climate. However, public discussion about adaptation is at an early stage in the U.S. and Canada (Natural Resources Canada, 2000), largely because national governments have focused public discussion on mitigation, with less attention to adaptation (Moser, 2005). Some public funds have been directed to research on impacts and adaptation, and

both countries have undertaken national assessments with a synthesis of the adaptation literature, but neither country has a formal adaptation strategy (Conference Board of Canada, 2006). Integrating perspectives on climate change into legislation and regulations has the potential to promote or constrain adaptive behaviour (Natural Resources Canada, 2000). North American examples of public policies that influence adaptive behaviour include water allocation law in the western U.S. (Scheraga, 2001), farm subsidies (Goklany, 2007), public flood insurance in the U.S. (Crichton, 2003), guidance on preservation of wetlands and emergency management.

### 14.5.3 Constraints and opportunities

*Social and cultural barriers*

High adaptive capacity, as in most of North America, should be an asset for coping with or benefiting from climate change. Capacity, however, does not ensure positive action or any action at all. Societal values, perceptions and levels of cognition shape adaptive behaviour (Schneider, 2004). In North America, information about climate change is usually not 'mainstreamed' or explicitly considered (Dougherty and Osaman Elasha, 2004) in the overall decision-making process (Slovic, 2000; Leiss, 2001). This can lead to actions that are maladapted, for example, development near floodplains or coastal areas known to be vulnerable to climate change. Water managers are unlikely to use climate forecasts, even when they recognise the vulnerability, unless the forecast information can fit directly into their everyday management decisions (Dow et al., 2007).

*Informational and technological barriers*

Uncertainty about the local impacts of climate change is a barrier to action (NRC, 2004). Incomplete knowledge of disaster safety options (Murphy, 2004; Murphy et al., 2005) further constrains adaptive behaviour. Climate change information must be available in a form that fits the needs of decision-makers. For example, insurance companies use climate models with outputs specifically designed to support decisions related to the risk of insolvency, pricing and deductibles, regulatory and rating agency considerations, and reinsurance (Swiss Re, 2005a). Some electrical utilities have begun to integrate climate model output into planning and management of hydropower production (Ouranos, 2004).

A major challenge is the need for efficient technology and knowledge transfer. In general, questions about responsibility for funding research, involving stakeholders, and linking communities, government and markets have not been answered (Ouranos, 2004). Another constraint is resistance to new technologies (e.g., genetically modified crops), so that some promising adaptations in the agricultural, water resource management and forestry sectors are unlikely to be realised (Goklany, 2000, 2001).

*Financial and market barriers*

In the U.S., recent spending on adaptation to extremes has been a sound investment, contributing to reduced fatalities, injuries and significant economic benefits. The Multihazard Mitigation Council (2005) found that US$3.5 billion in spending between 1993 and 2003 on programmes to reduce future damages from flooding, severe wind and earthquakes contributed US$14 billion in societal benefits. The greatest savings were in flood (5-fold) and wind (4-fold) damage reduction. Adaptation also benefited government as each dollar of spending resulted in US$3.65 in savings or increased tax revenue. This is consistent with earlier case studies; the Canadian $65 million invested in 1968 to create the Manitoba Floodway has prevented several billion dollars in flood damage (Duguid, 2002).

Economic issues are frequently the dominant factors influencing adaptive decisions. This includes community response to coastal erosion (Moser, 2000), investments to enhance water resource systems (Report of the Water Strategy Expert Panel, 2005), protective retrofits to residences (Simmons et al., 2002; Kunreuther, 2006), and changes in insurance practices (Kovacs, 2005a). The cost and availability of economic resources clearly influence choices (WHO, 2003), as does the private versus public identity of the beneficiaries (Moser, 2000).

Sometimes, financial barriers interact with the slow turnover of existing infrastructure (Figure 14.3). Extensive property damage in Florida during Hurricane Andrew in 1992 led to significant revisions to the building code. If all properties in southern Florida met this updated code in 1992, then property damage from Hurricane Andrew would have been lower by nearly 45% (AIR, 2002). Florida will, however, still experience extensive damage from hurricanes through damage to the large number of older homes and businesses. Other financial barriers come from the challenge property owners face in recovering the costs of protecting themselves. Hidden adaptations tend to be undervalued, relative to obvious ones. For example, homes with storm shutters sell for more than homes without this visible adaptation, while less visible retrofits, such as tie-down straps to hold the roof in high winds, add less to the resale value of the home, relative to their cost (Simmons et al., 2002).

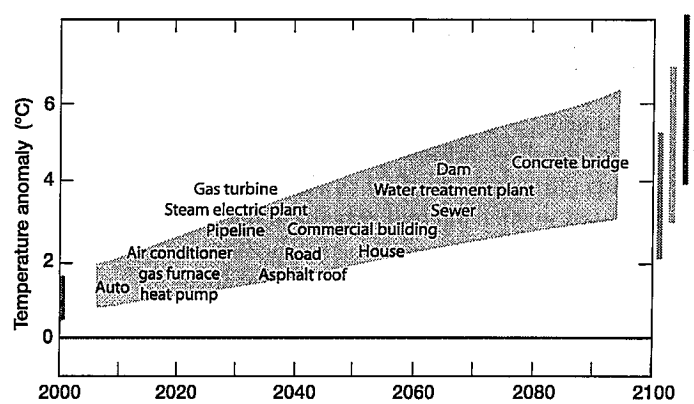


**Figure 14.3.** *Typical infrastructure lifetimes in North America (data from Lewis, 1987; Bettigole, 1990; EIA, 1999, 2001; Statistics Canada, 2001a; BEA, 2003), in relation to projected North American warming for 2000 to 2100 (relative to 1901-1950) for the A1B scenario, from the IPCC AR4 Multi-Model Dataset (yellow envelope). Measured and modelled anomalies for 2000 are shown with black and orange bars, respectively. Projected warming for 2091 to 2100 for the B1, A1B and A2 scenarios are indicated by the blue, yellow and red bars, respectively at the right (data from Christensen et al., 2007: Box 11.1 Figure 1).*

## 14.6 Case studies

Many of the topics discussed in this chapter have important dimensions, including interactions with other sectors, regions and processes, that make them difficult to assess from the perspective of a single sector. This chapter develops multi-sector case studies on three topics of special importance to North America – forest disturbances (see Box 14.1), water resources (using the Columbia River as an example) (see Box 14.2) and coastal cities (see Box 14.3).

## 14.7 Conclusions: implications for sustainable development

Climate change creates a broad range of difficult challenges that influence the attainment of sustainability goals. Several of the most difficult emerge from the long time-scale over which the changes occur (see Section 14.3) and the possible need for action well before the magnitude (and certainty) of the impacts is clear (see Section 14.5). Other difficult problems arise from the intrinsic global scale of climate change (EIA, 2005b). Because the drivers of climate change are truly global, even dedicated action at the regional scale has limited prospects for ameliorating regional-scale impacts. These two sets of challenges, those related to time-scale and those related to the global nature of climate change, are not in the classes that have traditionally yielded to the free-market mechanisms and political decision making that historically characterise Canada and the U.S. (see Section 14.5). Yet, the magnitude of the climate change challenge calls for proactive adaptation and technological and social innovation, areas where Canada and the U.S. have abundant capacity. An important key to success will be developing the capacity to incorporate climate change information into adaptation in the context of other important technological, social, economic and ecological trends.

The preceding sections describe current knowledge concerning the recent climate experience of North America, the impacts of the changes that have already occurred, and the potential for future changes. They also describe historical experience with and future prospects for dealing with climate impacts. The key points are:

- North America has experienced substantial social, cultural, economic and ecological disruption from recent climate-related extremes, especially storms, heatwaves and wildfires [14.2].
- Continuing infrastructure development, especially in vulnerable zones, will likely lead to continuing increases in economic damage from extreme weather [14.2.6, 14.4.6].
- The vulnerability of North America depends on the effectiveness of adaptation and the distribution of coping capacity, both of which are currently uneven and have not always protected vulnerable groups from adverse impacts of climate variability and extreme weather events [14.5].
- A key prerequisite for sustainability is 'mainstreaming' climate issues into decision making [14.5].
- Climate change will exacerbate stresses on diverse sectors in North America, including, but not limited to, urban centres, coastal communities, human health, water resources and managed and unmanaged ecosystems [14.4].
- Indigenous peoples of North America and those who are socially and economically disadvantaged are disproportionately vulnerable to climate change [14.2.6, 14.4.6].

## 14.8 Key uncertainties and research priorities

The major limits in understanding of climate change impacts on North America, and on the ability of its people, economies and ecosystems to adapt to these changes, can be grouped into seven areas.

- Projections of climate changes still have important uncertainties; especially on a regional scale (Christensen et al., 2007: Section 11.5.3). For North America, the greater uncertainty about future precipitation than about future temperature substantially expands the uncertainty of a broad range of impacts on ecosystems (see Section 14.4.2), hydrology and water resources (see Sections 14.4.1, 14.4.7), and on industries (see Sections 14.4.6, 14.4.7).
- North American people, economies and ecosystems tend to be much more sensitive to extremes than to average conditions [14.2]. Incomplete understanding of the relationship between changes in the average climate and extremes (Meehl et al., 2007: Section 10.3.6; Christensen et al., 2007: Section 11.5.3.3) limits our ability to connect future conditions with future impacts and the options for adaptation. There is a need for improved understanding of the relationship between changes in average climate and those extreme events with the greatest potential impact on North America, including hurricanes, other severe storms, heatwaves, floods, and prolonged droughts.
- For most impacts of climate change, we have at least some tools for estimating gradual change (see Section 14.4), but we have few tools for assessing the conditions that lead to tipping points, where a system changes or deteriorates rapidly, perhaps without further forcing.
- Most of the past research has addressed impacts on a single sector (e.g., health, transportation, unmanaged ecosystems). Few studies address the interacting responses of diverse sectors impacted by climate change, making it very difficult to evaluate the extent to which multi-sector responses limit options or push situations toward tipping points (see Section 14.4.9).
- Very little past research addresses impacts of climate change in a context of other trends with the potential to exacerbate impacts of climate change or to limit the range of response options (see Section 14.4.9) (but see Reid et al., 2005 for an important exception). A few North American examples of trends likely to complicate the development of strategies for dealing with climate change include continuing development in coastal areas (see Section 14.2.3), increasing demand on

freshwater resources (see Section 14.4.1), the accumulation of fuel in forest ecosystems susceptible to wildfire (see Box 14.1), and continued introductions of invasive species with the potential to disrupt agriculture and ecosystem processes (see Section 14.2.2, 14.2.4). In the sectors that are the subject of the most intense human management (e.g., health, agriculture, settlements, industry), it is possible that changes in technology or organisation could exacerbate or ameliorate impacts of climate change (see Section 14.4.9).

- Indirect impacts of climate change are poorly understood. In a world of ever-increasing globalisation, the future of North American people, economies and ecosystems is connected to the rest of the world through a dense network of cultural exchanges, trade, mixing of ecosystems, human migration and, regrettably, conflict (see Section 14.3). In this interconnected world, it is possible that profoundly important impacts of climate change on North America will be indirect consequences of climate change impacts on other regions, especially where people, economies or ecosystems are unusually vulnerable.
- Examples of North American adaptations to climate-related impacts are abundant, but understanding of the options for proactive adaptation to conditions outside the range of historical experience is limited (see Section 14.5).

All of these areas potentially interact, with impacts that are unevenly distributed among regions, industries, and communities. Progress in research and management is occurring in all these areas. Yet stakeholders and decision makers need information immediately, placing a high priority on strategies for providing useful decision support in the context of current knowledge, conditioned by an appreciation of the limits of that knowledge.

## References


ACIA, 2004: *(Arctic Climate Impact Assessment), Impacts of a Warming Arctic: Arctic Climate Impact Assessment*. Cambridge University Press, Cambridge, 146 pp.

ACIA, 2005: *Arctic Climate Impact Assessment*. Cambridge University Press, Cambridge, 1042 pp.

Adams, R.M., B.A. McCarl and L.O. Mearns, 2003: The effects of spatial scale of climate scenarios on economic assessments: An example from U.S. agriculture. *Clim. Change*, **60**, 131-148.

AIR, 2002: *Ten Years after Andrew: What Should We BePreparing for Now?*, AIR (Applied Insurance Research, Inc.) Technical Document HASR 0208, Boston, 9 pp. [Accessed 09.02.07: http://www.air-worldwide.com/_public/NewsData/000258/Andrew_Plus_10.pdf]

Alberta Environment, 2002: *South Saskatchewan River Basin Water Management Plan, Phase One - Water Allocation Transfers: Appendices*, Alberta Environment, Edmonton, Alberta.

Allen, D.M., D.C. Mackie and M. Wei, 2004a: Groundwater and climate change: a sensitivity analysis for the Grand Forks aquifer, southern British Columbia, Canada. *Hydrogeol. J.*, **12**, 270-290.

Allen, D.M., J. Scibek, M. Wei and P. Whitfield, 2004b: *Climate Change and Groundwater: A Modelling Approach for Identifying Impacts and Resource Sustainability in the Central Interior of British Columbia*, Climate Change Action Fund, Natural Resources Canada, Ottawa, Ontario, 404 pp.

Allen, J., 2003: *Drought Lowers Lake Mead*, NASA. [Accessed 09.02.07: http://earthobservatory.nasa.gov/Study/LakeMead/]

Allen, S.B., J.P. Dwyer, D.C. Wallace and E.A. Cook, 2003: Missouri River flood of 1993: Role of woody corridor width in levee protection. *J. Amer. Water Resour. Assoc.*, **39**, 923-933.

Andalo, C., J. Beaulieu and J. Bousquet, 2005: The impact of climate change on growth of local white spruce populations in Quebec, Canada. *Forest Ecol. Manag.*, **205**, 169-182.

Andrey, J. and B. Mills, 2003: Climate change and the Canadian transportation system: Vulnerabilities and adaptations. *Weather and Transportation in Canada*, J. Andrey and C. K. Knapper, Eds. University of Waterloo, Waterloo, Ontario, 235-279.

Andrey, J. and B. Mills, 2004: Transportation. *Climate Change Impacts and Adaptations: A Canadian Perspective*, D.S. Lemmen and F.J. Warren, Eds., Government of Canada, Ottawa, Ontario, 131-149. [Accessed 09.02.07: http://adaptation.nrcan.gc.ca/perspective/pdf/report_e.pdf]

Antle, J.M., S.M. Capalbo, E.T. Elliott and K.H. Paustian, 2004: Adaptation, spatial heterogeneity, and the vulnerability of agricultural systems to climate change and $CO_2$ fertilization: An integrated assessment approach. *Clim. Change*, **64**, 289-315.

Arctic Research Commission, 2003: *(U.S. Arctic Research Commission Permafrost Task Force), Climate Change, Permafrost, and Impacts on Civil Infrastructure*. Special Report 01-03, U.S. Arctic Research Commission, Arlington, Virginia, 72 pp. [Accessed 09.02.07: http://www.arctic.gov/files/ PermafrostForWeb.pdf]

Associated Press, 2002: Rough year for rafters. September 3, 2002.

Atkinson, J., J. DePinto and D. Lam. 1999: Water quality. *Potential Climate Change Effects on the Great Lakes Hydrodynamics and Water Quality*, D. Lam and W. Schertzer, Eds. American Society of Civil Engineers, Reston, Virginia.

Aw, J. and M.J. Kleeman, 2002: Evaluating the first-order effect of inter-annual temperature variability on urban air pollution. *J. Geophys. Res.*, **108**, doi:10.1029/2001JD000544.

Babaluk, J.A., J.D. Reist, J.D. Johnson and L. Johnson, 2000: First records of sockeye (*Oncorhynchus nerka*), and pink salmon (*O. gorbuscha*), from Banks Island and other records of Pacific salmon in Northwest territories. *Canada Arctic*, **53**, 161-164.

Bacal, R., 2000: *The Importance of Leadership in Managing Change*. [Accessed 09.02.07: http://performance-appraisals.org/Bacalsappraisalarticles/articles/leadchange.htm]

Bachelet, D., R.P. Neilson, J.M. Lenihan and R.J. Drapek, 2001: Climate change effects on vegetation distribution and carbon budget in the United States. *Ecosystems*, **4**, 164-185.

Bachelet, D., R.P. Neilson, J.M. Lenihan and R.J. Drapek, 2004: Regional differences in the carbon source-sink potential of natural vegetation in the U.S.. *Environ. Manage.*, **33**, S23-S43. doi: 10.1007/s00267-003-9115-4.

Badeck, F.W., A. Bondeau, K. Bottcher, D. Doktor, W. Lucht, J. Schaber and S. Sitch, 2004: Responses of spring phenology to climate change. *New Phytol.*, **162**, 295-309.

Baldocchi, D. and R. Valentini, 2004: Geographic and temporal variation of carbon exchange by ecosystems and their sensitivity to environmental perturbations. *The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World*, C.B. Field and M.R. Raupach, Eds. Island Press, Washington, District of Columbia, 295-316.

Balling, R.C. and R.S. Cerveny, 2003: Compilation and discussion of trends in severe storms in the United States: Popular perception versus climate reality. *Natural Hazards*, **29**, 103-112.

Barber, V.A., G.P. Juday and B.P. Finney, 2000: Reduced growth of Alaskan white spruce in the twentieth century from temperature-induced drought stress. *Nature*, **405**, 668-673.

Barnett, J., 2003: Security and climate change. *Global Environ. Change*, **13**, 7-17.

Barron, E.J., 2001: Chapter 4: Potential consequences of climate variability and change for the northeastern United States. *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change. Report for the US Global Change Research Program*, Cambridge University Press, Cambridge, 109-134. [Accessed 09.02.07: http://www.usgcrp.gov/usgcrp/Library/nationalassessment/04NE.pdf]

BC Stats, 2003: *Tourism Sector Monitor – November 2003*, British Columbia Ministry of Management Services, Victoria, 11 pp. [Accessed 09.02.07: http://www.bcstats.gov.bc.ca/pubs/tour/tsm0311.pdf]

BEA, 2003: *(U.S. Bureau of Economic Analysis), Fixed Assets and Consumer Durable Goods in the United States, 1925-1997*. September 2003, 'Derivation of Depreciation Estimates', pp. M29-M34.

Beaubien, E.G. and H.J. Freeland, 2000: Spring phenology trends in Alberta, Canada: Links to ocean temperature. *Int. J. Biometeorol.*, **44**, 53-59.

Beaulac, I. and G. Doré, 2005: *Impacts du Dégel du Pergélisol sur les Infrastructures de Transport Aérien et Routier au Nunavik et Adaptations - état des connaissances*, Facultées Sciences et de Génie, Université Laval, Montreal, Quebec, 141 pp.

Beebee, T.J.C., 1995: Amphibian breeding and climate. *Nature*, **374**, 219-220.

Bélanger, G., P. Rochette, Y. Castonguay, A. Bootsma, D. Mongrain and A.J. Ryand, 2002: Climate change and winter survival of perennial forage crops in Eastern Canada. *Agron. J.*, **94**, 1120-1130.

Bell, M.L., R. Goldberg, C. Hogrefe, P. Kinney, K. Knowlton, B. Lynn, J. Rosenthal, C. Rosenzweig and J.A. Patz, 2007: Climate change, ambient ozone, and health in 50 U.S. cities. *Climatic. Change*, **82**, 61-76.

Bernatchez, P. and J.-M.M. Dubois, 2004: Bilan des connaissances de la dynamique de l'érosion des côtes du Québec maritime laurentien. *Géograph. Phys. Quater.*, **58**, 45-71.

Berthelot, M., P. Friedlingstein, P. Ciais, P. Monfray, J.L. Dufresen, H.L. Treut and L. Fairhead, 2002: Global response of the terrestrial biosphere and $CO_2$ and climate change using a coupled climate-carbon cycle model. *Global Biogeochem. Cy.*, **16**, 10.1029/2001GB001827.

Bertness, M.D., P.J. Ewanchuk and B.R. Silliman, 2002: Anthropogenic modification of New England salt marsh landscapes. *Proc. Nat. Acad. Sci.*, **99**, 1395-1398.

Bettigole, N.H., 1990: Designing Bridge Decks to Match Bridge Life Expectancy. in *Extending the Life of Bridges, ASTM Special Technical Publication 1100*, ASTM Committee D-4 on Road and Paving Materials, Philadelphia, Pennsylvania, 70-80.

Bixel, P.B. and E.H. Turner, 2000: *Galveston and the 1900 Storm: Catastrophe and Catalyst*. University of Texas Press, Austin, Texas, 174 pp.

Boisvenue, C. and S.W. Running, 2006: Impacts of climate change on natural forest productivity - evidence since the middle of the 20th century. *Global Change Biol.*, **12**, 862-882.

Bonsal, B.R. and T.D. Prowse, 2003: Trends and variability in spring and autumn 0°C-isotherm dates over Canada. *Clim. Change*, **57**, 341-358.

Bonsal, B.R., X. Zhang, L.A. Vincent and W.D. Hood, 2001: Characteristics of daily and extreme temperatures over Canada. *J. Climate*, **14**, 1959-1976.

Bonsal, B., G. Koshida, E.G. O'Brien and E. Wheaton, 2004: Droughts. *Threats to Water Availability in Canada*, Environment Canada, Ed., Environment Canada, National Water Resources Institute and Meteorological Service of Canada, NWRI Scientific Assessment Report Series No. 3, ACSD Science Assessment Series No.1, Burlington, Ontario, 19-25.

Borwick, J., J. Buttle and M.S. Ridgway, 2006: A topographic index approach for identifying groundwater habitat of young-of-year brook trout (*Salvelinus fontinalis*) in the land-lake ecotone. *Can. J. Fish. Aquatic Sci.*, **63**, 239-253.

Breslow, P.B. and D.J. Sailor, 2002: Vulnerability of wind power resources to climate change in the continental United States. *Renew. Energ.*, **27**, 585-598.

Bromirski, P.D., R.E. Flick and D.R. Cayan, 2003: Storminess variability along the California coast: 1958-2000. *J. Climate*, **16**, 982-993.

Brown, J.L., S.H. Li and B. Bhagabati, 1999: Long-term trend toward earlier breeding in an American bird: A response to global warming? *Proc. Nat. Acad.Sci.*, **96**, 5565-5569.

Brown, R.A., N.J. Rosenberg, C.J. Hays, W.E. Easterling and L.O. Mearns, 2000: Potential production and environmental effects of switchgrass and traditional crops under current and greenhouse-altered climate in the central United States: a simulation study. *Agric. Ecosyst. Environ.*, **78**, 31-47.

Brown, T. J., B. L. Hall and A. L. Westerling, 2004: The impact of twenty-first century climate change on wildland fire danger in the western United States: An applications perspective. *Clim. Change*, **62**, 365-388.

Brownstein, J.S., T.R. Holford and D. Fish, 2003: A climate-based model predicts the spatial distribution of Lyme disease vector *Ixodes scapularis* in the United States. *Environ. Health. Perspect.*, **111**, 1152-1157.

Bruce, J.P., 1999: Disaster loss mitigation as an adaptation to climate variability and change. *Mitigation Adapt. Strategies Global Change*, **4**, 295-306.

Bureau of Transportation Statistics, 2006: *Economic Indexes: Transportation Services Index*. United States Department of Transportation, Washington, District of Columbia. [Accessed 09.02.07: http://www.bts.gov/publications/white_house_economic_statistics_briefing_room/october_2005/html/transportation_services_index.html]

Burkett, V.R., 2002: The Potential Impacts of Climate Change on Transportation. Workshop Summary and Proceedings, October 1-2, 2002, DOT Center for Climate Change and Environmental Forecasting - Federal Research Partnership Workshop, Washington, District of Columbia. [Accessed 09.02.07: http://climate.volpe.dot.gov/workshop1002/]

Burkett, V.R., D.A. Wilcox, R. Stottlemyer, W. Barrow, D. Fagre, J. Baron, J. Price, J.L. Nielsen, C.D. Allen, D.L. Peterson, G. Ruggerone and T. Doyle, 2005: Nonlinear dynamics in ecosystem response to climatic change: Case studies and policy implications. *Ecol. Complexity*, **2**, 357-394.

Burleton, D., 2002: *Slowing Population, Ageing Workforce Trends More Severe in Canada than in the U.S.*, Executive Summary for TD Economics, Toronto, Ontario, 3 pp.

Burton, I. and B. Lim, 2005: Achieving adequate adaptation in agriculture. *Clim. Change*, **70**, 191-200.

Burton, I., S. Huq, B. Lim, O. Pilifosova and E.L. Schipper, 2002: From impacts assessment to adaptation priorities: the shaping of adaptation policy. *Climate Policy*, **2**, 145-159.

Business Week, 2005: A Second Look at Katrina's Cost. *Business Week*. September 13, 2005. [Accessed 09.02.07: http://www.businessweek.com/bwdaily/dnflash/sep2005/nf20050913_8975_db082.htm]

Butler, A., 2002: Tourism burned: visits to parks down drastically, even away from flames. *Rocky Mountain News*. July 15, 2002.

Butler, C.J., 2003: The disproportionate effect of global warming on the arrival dates of short-distance migratory birds in North America. *Ibis*, **145**, 484-495.

Buttle, J., J.T. Muir and J. Frain, 2004: Economic impacts of climate change on the Canadian Great Lakes hydro–electric power producers: A supply analysis. *Can. Water Resour. J.*, **29**, 89-109.

Byers, S., O. Snowe, B. Carr, J.P. Holdren, M.K. Kok-Peng, N. Kosciusko-Morizet, C. Martin, T. McMichael, J. Porritt, A. Turner, E.U. von Weizsäcker, N. Weidou, T.E. Wirth and C. Zoi, 2005: *Meeting the Climate Challenge, Recommendations of the International Climate Change Taskforce*, International Climate Change Taskforce, The Institute for Public Policy Research, London, 40 pp. [Accessed 09.02.07: http://www.americanprogress.org/atf/cf/%7BE9245FE4-9A2B-43C7-A521-5D6FF2E06E03%7D/CLIMATECHALLENGE.PDF]

California Regional Assessment Group, 2002: *The Potential Consequences of Climate Variability and Change for California: The California Regional Assessment*. National Center for Ecological Analysis and Synthesis, University of California Santa Barbara, Santa Barbara, California, 432 pp. [Accessed 09.02.07: http://www.ncgia.ucsb.edu/pubs/CA_Report.pdf]

Campbell, P.R., 1996: *Population Projections for States by Age, Sex, Race, and Hispanic Origin: 1995 to 2025*, U.S. Bureau of the Census, Population Division, Washington, District of Columbia, PPL-47. [Accessed 09.02.07: http://www.census.gov/population/www/projections/ppl47.html]

Carbone, G.J., W. Kiechle, L. Locke, L.O. Mearns, L. McDaniel and M.W. Downton, 2003: Response of soybean and sorghum to varying spatial scales of climate change scenarios in the southeastern United States. *Clim. Change*, **60**, 73-98.

Carroll, A.L., S.W. Taylor, J. Regniere and L. Safranyik, 2003: Effects of climate change on range expansion by the mountain pine beetle of British Columbia. *Mountain Pine Beetle Symposium*. Canadian Forest Service, Pacific Forestry Centre, Kelowna, British Columbia, 223-232.

Caspersen, J.P., S.W. Pacala, J.C. Jenkins, G.C. Hurtt, P.R. Moorcroft and R.A. Birdsey, 2000: Contributions of land-use history to carbon accumulation in U.S. forests. *Science*, **290**, 1148-1151.

Casselman, J.M., 2002: Effects of temperature, global extremes, and climate change on year-class production of warmwater, coolwater, and coldwater fishes in the Great Lakes basin. *Amer. Fish. Soc. Symp.*, **32**, 39-60.

Cayan, D., M. Tyree and M. Dettinger, 2003: *Climate Linkages to Female Culex Cx. Tarsalis Abundance in California*. California Applications Program (UCSD), San Diego, California. [Accessed 09.02.07: http://meteora.ucsd.edu/cap/mosq_climate.html]

Cayan, D.R., S.A. Kammerdiener, M.D. Dettinger, J.M. Caprio and D.H. Peterson, 2001: Changes in the onset of spring in the western United States. *Bull. Amer. Meteor. Soc.*, **82**, 399-415.

CCME, 2003: *Climate, Nature, People: Indicators of Canada's Changing Climate*. Climate Change Indicators Task Group of the Canadian Council of Ministers of the Environment, Canadian Council of Ministers of the Environment Inc., Winnipeg, Canada, 51 pp.

CDLI, 1996: Collapse of the Resource Base. *The History of the Northern Cod Fishery*, The Centre for Distance Learning and Innovation, Newfoundland and Labrador Department of Education St. Johns, Newfoundland. [Accessed 09.07.02: http://www.cdli.ca/cod/.]

Census Bureau, 2000: NP-T1. Annual Projections of the Total Resident Population as of July 1: Middle, Lowest, Highest, and Zero International Migration Series, 1999 to 2100. Population Division, U.S. Census Bureau, Washington, District of Columbia. [Accessed 09.02.07: http://www.census.gov/population/projections/nation/summary/np-t1.txt.]

Census Bureau, 2004: *(U.S. Census Bureau), American Housing Survey for the United States: 2003*, U.S. Census Bureau, Washington, District of Columbia, 592 pp. [Accessed 09.02.07: http://www.census.gov/hhes/www/housing/ahs/ahs03/ahs03.html]

CERES, 2004: *Investor Guide to Climate Risk: Action Plan and Resource for Plan*

*Sponsors, Fund Managers and Corporations*, D.G. Cogan, Ed., CERES, Inc., Boston, Massachusetts, 20 pp. [Accessed 09.02.07: http://www.ceres.org/pub/docs/Ceres_investor_guide_072304.pdf]

ngnon, S.A., 1993: Changes in climate and levels of Lake Michigan: shoreline impacts at Chicago. *Clim. Change*, **23**, 213-230.

Changnon, S.A., 2003: Shifting economic impacts from weather extremes in the United States: A result of societal changes, not global warming. *Nat. Hazards*, **29**, 273-290.

Changnon, S.A., 2005: Economic impacts of climate conditions in the United States: Past, present, and future - An editorial essay. *Clim. Change*, **68**, 1-9.

Changnon, S.A. and M.H. Glantz, 1996: The Great Lakes diversion at Chicago and its implications for climate change. *Clim. Change*, **32**, 199-214.

Changnon, S.A. and D. Changnon, 2000: Long-term fluctuations in hail incidences in the United States. *J. Climate*, **13**, 658-664.

Chapin, F.S., III, E.S. Zavaleta, V.T. Eviner, R.L. Naylor, P.M. Vitousek, H.L. Reynolds, D.U. Hooper, S. Lavorel, O.E. Sala, S E. Hobbie, M.C. Mack and S. Díaz, 2000: Consequences of changing biodiversity. *Nature*, **405**, 234 - 242.

Charron, D.F., 2002: Potential impacts of global warming and climate change on the epidemiology of zoonotic diseases in Canada. *Can. J. Public Health*, **93**, 334-335.

Chen, C., D. Gillig and B. McCarl, 2001: Effects of climatic change on a water dependent regional economy: a study of the Texas Edwards aquifer. *Clim. Change*, **49**, 397-409.

Cheng, S., M. Campbell, Q. Li, L. Guilong, H. Auld, N. Day, D. Pengelly, S. Gingrich, J. Klaassen, D. MacIver, N. Comer, Y. Mao, W. Thompson and H. Lin, 2005: Differential and Combined Impacts of Winter and Summer Weather and Air Pollution due to Global Warming on Human Mortality in South-Central Canada. Technical report (Health Policy Research Program: Project Number 6795-15-2001/4400011).

Chmura, G.L. and G.A. Hung, 2004: Controls on salt marsh accretion: A test in salt marshes of Eastern Canada. *Estuaries*, **27**, 70-81.

Chmura, G.L., S.C. Anisfeld, D.R. Cahoon and J.C. Lynch, 2003: Global carbon sequestration in tidal, saline wetland soils. *Global Biogeochem. Cycles*, **17**, doi:10.1029/2002GB001917.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menendez, J. Räisänen, A. Rinke, A. Sarr and P. Whetton, 2007: Regional climate projections. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Eds., Cambridge University Press, Cambridge and New York, 847-940.

Christensen, N.S., A.W. Wood, N. Voisin, D.P. Lettenmaier and R.N. Palmer, 2004: The effects of climate change on the hydrology and water resources of the Colorado River basin. *Clim. Change*, **62**, 337-363.

Chu, C., C.K. Minns and N.E. Mandrak, 2003: Comparative regional assessment of factors impacting freshwater fish biodiversity in Canada. *Canadian Journal of Fisheries and Aquatic Sciences*, **60**, 624-634.

Chu, C., N.E. Mandrak and C.K. Minns, 2005: Potential impacts of climate change on the distributions of several common and rare freshwater fishes in Canada. *Divers. Distrib.*, **11**, 299-310.

Church, J.A., N.J. White, R. Coleman, K. Lambeck and J.X. Mitrovica, 2004: Estimates of the regional distribution of sea level rise over the 1950-2000 period. *J. Climate*, **17**, 2609-2625.

City of New York, 2005: *New York City's Water Supply System*. The City of New York Department of Environmental Protection, New York, New York. [Accessed 09.07.02: http://www.ci.nyc.ny.us/html/dep/html/watersup.html]

Clark, G.E., S.C. Moser, S.J. Ratick, K. Dow, W.B. Meyer, S. Emani, W. Jin, J.X. Kasperson, R.E. Kasperson and H.E. Schwarz, 1998: Assessing the vulnerability of coastal communities to extreme storms: the case of Revere, MA, USA. *Mitigation Adap. Strategies Global Change*, **3**, 59-82.

Clark, M.E., K.A. Rose, D.A. Levine and W.W. Hargrove, 2001: Predicting climate change effects on Appalachian trout: Combining GIS and individual-based modeling. *Ecol. Appl.*, **11**, 161-178.

Clayton, A., J. Montufar, J. Regehr, C. Isaacs and R. McGregor, 2005: Aspects of the potential impacts of climate change on seasonal weight limits and trucking in the Prairie region, Prepared for Natural Resources Canada. [Accessed 10.06.07: http:www.adaptation.nrcan.gc.ca/projdb/pdf/135a_e.pdf]

Co-operative Programme on Water and Climate, 2005: *Workshop 3, Climate Variability, Water Systems and Management Options*, Co-operative Programme on Water and Climate, Delft, The Netherlands, 5 pp.

Cohen, S., K. Miller, K. Duncan, E. Gregorich, P. Groffman, P. Kovacs, V. Magaña, D. McKnight, E. Mills and D. Schimel. 2001: North America. *Climate Change 2001: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, J.J. McCarthy, O.F. Canziani, N.A. Leary, D.J. Dokken and K.S. White, Eds., Cambridge University Press, Cambridge, 735-800.

Cohen, S.J., R. de Loë, A. Hamlet, R. Herrington, L.D. Mortsch and D. Shrubsole, 2003: Integrated and cumulative threats to water availability. *Threats to Water Availability in Canada*, National Water Research Institute, Burlington, Ontario, 117-127. [Accessed 09.02.07: http://www.nwri.ca/threats2full/ ThreatsEN_03web.pdf]

Cohen, S., D. Neilsen, S. Smith, T. Neale, B. Taylor, M. Barton, W. Merritt, Y. Alila, P. Shepherd, R. McNeill, J. Tansey, J. Carmichael and S. Langsdale, 2006: Learning with local help: expanding the dialogue on climate change and water management in the Okanagan Region, British Columbia, Canada. *Clim. Change*, **75**, 331-358.

Cole, H., V. Colonell and D. Esch, 1998: *The economic impact and consequences of global climate change on Alaska's infrastructure*. Assessing the Consequences of Climate Change for Alaska and the Bering Sea Region, 1999, Center for Global Change and Arctic System Research, University of Alaska Fairbanks, Fairbanks, Alaska. 3 pp. [Accessed 09.02.07: http://www.besis.uaf.edu/besis-oct98-report/Infrastructure-1.pdf]

Columbia University Mailman School of Public Health, 2006: *On The Edge – The Louisiana Child & Family Health Study*, Columbia University Mailman school of Public Health, New York, New York.

Conference Board of Canada, 2006: *Adapting to Climate Change: Is Canada Ready?*, The Conference Board of Canada, Ottawa, Ontario.

Cooke, S.J. and I.G. Cowx, 2004: The role of recreational fishing in global fish crises. *BioScience*, **54**, 857-859.

Cowell, P.J., M.J.F. Stive, A.W. Niedoroda, H.J. de Vriend, D.J.P. Swift, G.M. Kaminsky and M. Capobianco, 2003: The coastal tract (part 1): a conceptual approach to aggregated modeling of low-order coastal change. *J. Coastal Res.*, **19**, 812-827.

Cox, P.M., R.A. Betts, C.D. Jones, S.A. Spall and I.J. Totterdell, 2000: Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. *Nature*, **408**, 184-187.

Crichton, D., 2003: Insurance and Maladaptation. Preprints, *United Nations Framework Convention on Climate Change Workshop*, Bonn, Germany.

Croley, T.E., II, 2003: Great Lakes Climate Change Hydrological Impact Assessment, IJC Lake Ontario—St. Lawrence River Regulation Study. NOAA Tech. Memo. GLERL-126, Great Lakes Environmental Research Laboratory, Ann Arbor, Michigan, 84 pp.

Croley, T.E. and C.L. Luukkonen, 2003: Potential effects of climate change on ground water in Lansing, Michigan. *J. Amer. Water Resour. Assoc.*, **39**, 149-163.

Crozier, L., 2003: Winter warming facilitates range expansion: Cold tolerance of the butterfly *Atalopedes campestris*. *Oecologia*, **135**, 648-656.

Currie, D.J., 2001: Projected effects of climate change on patterns of vertebrate and tree species in the conterminous United States. *Ecosystems*, **4**, 216-225.

Curriero, F.C., J.A. Patz, J.B. Rose and S. Lele, 2001: The association between extreme precipitation and waterborne disease outbreaks in the United States, 1948-1994. *Am. J. Public Health*, **91**, 1194-1199.

Curriero, F.C., K.S. Heiner, J.M. Samet, S.L. Zeger, L. Strung and J.A. Patz, 2002: Temperature and mortality in 11 cities of the eastern United States. *Am. J. Epidemiol.*, **155**, 80-87.

Cutter, S.L., J.T. Mitchell and M.S. Scott, 2000: Revealing the vulnerability of people and place: a case study of Georgetown County, South Carolina. *Ann. Assoc. Am. Geog.*, **90**, 713-737.

D'Arcy, P., J.-F. Bibeault and R. Raffa, 2005: *Changements climatiques et transport maritime sur le Saint-Laurent. Étude exploratoire d'options d'adaptation*. Réalisé pour le Comité de concertation navigation du Plan d'action Saint-Laurent, Montreal, Quebec, 140 pp. [Accessed 09.02.07: http://www.ouranos.ca/doc/Rapports%20finaux/Final_Darcy.pdf

Dale, V.H., L.A. Joyce, S. McNulty, R.P. Neilson, M.P. Ayres, M.D. Flannigan, P.J. Hanson, L.C. Irland, A.E. Lugo, C.J. Peterson, D. Simberloff, F.J. Swanson, B.J. Stocks and B.M. Wotton, 2001: Climate change and forest disturbances. *BioScience*, **51**, 723-734.

Denault, C., R.G. Millar and B.J. Lence, 2002: Climate change and drainage infrastructure capacity in an urban catchment. *Proc. Annual Conference of the Canadian Society for Civil Engineering*, June 5-6, 2002, Montreal, Quebec, Canada, 10 pp. [Accessed 09.02.07: http://www.c-ciarn.mcgill.ca/millar.pdf]

Devon, 2005: *A Warm Response: Our Climate Change Challenge*. Devon County

Council, Devon, 122 pp. [Accessed 09.02.07: http://www.devon.gov.uk/climate-change-strategy.pdf]

DFO-MPO, 2002: *DFO's Statistical Services*. Department of Fisheries and Oceans. [Accessed 09.02.07: www.dfo-mpo.gc.ca/communic/statistics/]

Dlugolecki, A.F., 2005: What is stopping the finance sector? *IEEE Power Engineering Society General Meeting*, **3**, 2951-2953.

Dohm, D.J. and M.J. Turell, 2001: Effect of incubation at overwintering temperatures on the replication of West Nile virus in New York *Culex pipiens* (Diptera: Culicidae). *J. Med. Entomol.*, **38**, 462-464.

Dohm, D.J., M.L. O'Guinn and M.J. Turell, 2002: Effect of environmental temperature on the ability of *Culex pipiens* (Diptera: Culicidae) to transmit West Nile virus. *J. Med. Entomol.*, **39**, 221-225.

DOI, 2002: *2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation*. U.S. Dept. Interior, Fish and Wildlife Service and U.S. Dept. Commerce, U.S. Census Bureau, Washington, District of Columbia, 170 pp. [Accessed 09.02.07: http://www.census.gov/prod/2002pubs/FHW01.pdf]

Dolan, A.H. and I.J. Walker, 2006: Understanding vulnerability of coastal communities to climate change related risks. *J. Coastal Res.*, **SI 39** 1317-1324.

Dolney, T.J. and S.C. Sheridan, 2006: The relationship between extreme heat and ambulance response calls for the city of Toronto, Ontario, Canada. *Environ. Res.*, **101**, 94-103.

Donnelly, J.P. and M.D. Bertness, 2001: Rapid shoreward encroachment of salt marsh cordgrass in response to accelerated sea-level rise. *Proc. Nat. Acad. Sci.*, **98**, 14218-14223.

Donnelly, J.P., P. Cleary, P. Newby and R. Ettinger, 2004: Coupling instrumental and geological records of sea-level change: Evidence from southern New England of an increase in the rate of sea-level rise in the late 19th century. *Geophys. Res. Lett.*, **31**, doi:10.1029/2003GL018933.

Dougherty, B. and B. Osaman Elasha, 2004: Mainstreaming adaptation into national development plans. *Report of the Second AIACC Africa and Indian Ocean Island Regional Workshop*, University of Senegal, Dakar, 74 pp. [Accessed 09.02.07: http://www.aiaccproject.org/meetings/Dakar_04/Dakar_Final.pdf]

Douglas, B.C. and W.R. Peltier, 2002: The puzzle of global sea-level rise. *Phys. Today*, **55**, 35-40.

Dow, K., R.E. O'Connor, B. Yarnal, G.J. Carbone and C.L. Jocoy, 2007: Why worry? Community water system managers' perceptions of climate vulnerability. Global Environ. Change, **17**, 228-237.

du Vair, P., D. Wickizer and M.J. Burer, 2002: Climate change and the potential implications for California's transportation system. *The Potential Impacts of Climate Change on Transportation, Federal Research Partnership Workshop*, October 1-2, 2002, Washington, District of Columbia, 125-135. [Accessed 09.02.07: http://climate.volpe.dot.gov/workshop1002/]

Duguid, T., 2002: Flood Protection Options for the City of Winnipeg, Report to the Government of Manitoba on Public Meetings, Winnepeg, Manitoba, Canada, 31 pp. [Accessed 09.02.07: http://www.cecmanitoba.ca/Reports/PDF/ACF44E4.pdf]

Dunn, P.O. and D.W. Winkler, 1999: Climate change has affected the breeding date of tree swallows throughout North America. *Proc. R. Soc. Lond. B*, **266**, 2487-2490.

Dupigny-Giroux, L.-A., 2001: Towards characterizing and planning for drought in Vermont – Part I: A climatological perspective. *J. Amer. Water Resour. Assoc.*, **37**, 505-525.

Dwight, R.H., J.C. Semenza, D.B. Baker and B.H. Olson, 2002: Association of urban runoff with coastal water quality in Orange County, California. *Water Environ. Res.*, **74**, 82-90.

Dyke, A.S. and W.R. Peltier, 2000: Forms, response times and variability of relative sea-level curves, glaciated North America. *Geomorphology*, **32**, 315-333.

Easterling, D.R., 2002: Recent changes in frost days and the frost-free season in the United States. *Bull. Amer. Meteor. Soc.*, **83**, 1327-1332.

Easterling, D.R., G.A. Meehl, C. Parmesan, S.A. Changnon, T.R. Karl and L.O. Mearns, 2000: Climate extremes: Observations, modeling, and impacts. *Science*, **289**, 2068-2074.

Easterling, W.E., N. Chhetri and X.Z. Niu, 2003: Improving the realism of modeling agronomic adaptation to climate change: Simulating technological substitution. *Clim. Change*, **60**, 149-173.

Easterling, W., B. Hurd and J. Smith, 2004: *Coping with Global Climate Change: The Role of Adaptation in the United States*, Pew Center on Global Climate Change, Arlington, Virginia, 52 pp. [Accessed 09.02.07: http://www.pewclimate.org/document.cfm?documentID=319]

Ebi, K.L., T.J. Teisberg, L.S. Kalkstein, L. Robinson and R.F. Weiher, 2004: Heat watch/warning systems save lives: Estimated costs and benefits for Philadelphia 1995-98. *Bull. Amer. Meteor. Soc.*, **85**, 1067-1073.

Economic Research Service, 2006: Farm Income and Costs: Farm Sector Income Forecast. United States Department of Agriculture Economic Research Service, Washington, District of Columbia. [Accessed 09.02.07: http://www.ers.usda.gov/briefing/farmincome/data/nf_t2.htm]

Edmonds, J.A., 2004: Unanticipated consequences: Thinking about ancillary benefits and costs of greenhouse gas emissions mitigation. *The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World*, C.B. Field and M.R. Raupach, Eds., Island Press, Washington, District of Columbia, 419-430.

Edmonds, J.A. and N.J. Rosenberg, 2005: Climate change impacts for the conterminous USA: An integrated assessment summary. *Clim. Change*, **69**, 151-162.

EEA, 2005: Hurricane damage to natural gas infrastructure and its effect on U.S. natural gas market. EEA (Energy and Environmental Analysis, Inc.), Arlington, Virginia, 49 pp. [Accessed 09.02.07: http://www.ef.org/documents/hurricanereport_final.pdf]

EEI, 2005: *After the Disaster: Utility Restoration Cost Recovery*. Edison Electric Institute (EEI), Washington, District of Columbia, 27 pp. [Accessed 09.02.07: http://www.eei.org/industry_issues/reliability/nonav_reliability/Utility_Restoration_Cost_Recovery.pdf]

Eggers, D., 2006: *Run Forecasts and Harvest Projections for 2006 Alaskan Salmon Fisheries and Review of the 2005 Season*. Alaska Department of Fish and Game, Special Publication No. 06-07, Juneau, Alaska, 83 pp.

Eheart, J.W., A.J. Wildermuth and E.E. Herricks, 1999: The effects of climate change and irrigation on criterion low streamflows used for determining total maximum daily loads. *J. Amer. Water Resour. Assoc.*, **35**, 1365-1372.

EIA, 1999: Commercial Building Energy Consumption Survey: Building Characteristics tables. Table B-9. Year Constructed, Floorspace, 1999. U.S. Energy Information Administration, Washington, District of Columbia. [Accessed 09.02.07: http://www.eia.doe.gov/emeu/cbecs/detailed_tables_1999.html]

EIA, 2001: 2001 Residential Energy Consumption Survey: housing characteristics tables, Table HC1-2a. Housing unit characteristics by year of construction, million U.S. households, 2001. U.S. Energy Information Administration, Washington, District of Columbia.

EIA, 2005a: *Short Term Energy Outlook, December 2005*. U.S. Energy Information Administration, Washington, District of Columbia, 49 pp. [Accessed 09.02.07: http://www.eia.doe.gov/pub/forecasting/steo/oldsteos/dec05.pdf]

EIA, 2005b: *International Energy Annual*. U.S. Energy Information Administration, May 2005. [Accessed 09.02.07: http://www.eia.doe.gov/iea/]

Elliott, G.P. and W.L. Baker, 2004: Quaking aspen at treeline: A century of change in the San Juan Mountains, Colorado, USA. *J. Biogeog.*, **31**, 733-745.

Elsasser, H., R. Bürki and B. Abegg, 2003: Climate change and winter sports: environmental and economic threats. *Fifth World Conference on Sport and the Environment*, Turin, IOC/UNEP, 8 pp. [Accessed 09.02.07: www.unep.org/sport_env/Documents/torinobuerki.doc]

Emanuel, K., 2005: Increasing destructiveness of tropical cyclones over the past 30 years. *Nature*, **436**, 686-688.

Enarson, E., 2002: Gender Issues in Natural Disasters: Talking Points on Research Needs. *Crisis, Women and Other Gender Concerns*, Working Paper 7, Recovery and Reconstruction Department, ILO, Geneva, 5-12.

Environment Canada, 2004: *Threats to water availability in Canada*. National Water Research Institute, Burlington, Ontario,150 pp. [Accessed 09.02.07: http://www.nwri.ca/threats2full/ThreatsEN_03web.pdf]

EPA, 1999: Global Climate Change: What Does it Mean for South Florida and the Florida Keys? *Report of Florida Coastal Cities Tour*, U.S. Environmental Protection Agency, Washington, District of Columbia. [Accessed 09.02.07: http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BUKPX/ $File/florida.pdf]

EPRI, 2003: *Electricity Sector Framework for the Future. Volume 1. Achieving the 21st Century Transformation*. Electric Power Research Institute, Palo Alto, California, 77 pp. [Accessed 09.02.07: http://www.globalregulatorynetwork.org/PDFs/ESFF_volume1.pdf]

Epstein, P. and E. Mills, 2005: *Climate Change Futures: Health, Ecological and Economic Dimensions*. Harvard Medical School, Boston, Massachusetts, 142 pp. [Accessed 09.02.07: http://chge.med.harvard.edu/research/ccf/documents/ccf_final_report.pdf]

Fang, X. and H.G. Stefan, 1999: Projections of climate change effects on water temperature characteristics of small lakes in the contiguous U.S. *Clim. Change*, **42**, 377-412.

Fang, X., H.G. Stefan, J.G. Eaton, J.H. McCormick and S.R. Alam, 2004: Simulation of thermal/dissolved oxygen habitat for fishes in lakes under different climate scenarios - Part 1. Cool-water fish in the contiguous US. *Ecol. Model.*, **172**, 13-37.

FEMA, 2006: *Flood Map Modernization: Mid-Course Adjustment,* Federal Emergency Management Agency, Washington, District of Columbia, 70 pp.

Fang, S. and Q. Hu, 2004: Changes in agro-meteorological indicators in the contiguous United States: 1951–2000. *Theor. Appl. Climatol.*, **78**, 247-264.

Fillion, Y., 2000: Climate change: implications for Canadian water resources and hydropower production. *Can. Water Resour. J.*, **25**, 255-270.

FireSmart, 2005: *Fire Smart*. Government of Alberta, Edmonton, Canada. [Accessed 09.02.07: http://www.partnersinprotection.ab.ca/downloads/]

FireWise, 2005: *Fire Wise*. National Fire Protection Association, Quincy. Massachusetts. [Accessed 09.02.07: http://www.firewise.org/]

Fischhoff, B. 2006: Behaviorly realistic risk management. *On Risk and Disaster*, H. Kunreuther, R. Danielsand D. Kettle, Eds., University of Pennsylvania Press, Philadelphia.

Fisher, A., 2000: Preliminary findings from the mid-Atlantic regional assessment. *Climate Res.*, **14**, 261-269.

Fisheries and Oceans Canada, 2000: *Dhaliwal moves ahead with $15M in federal funding for emergency dredging in the Great Lakes*. [Accessed 09.02.07: http://www.dfo-mpo.gc.ca/media/newsrel/2000/hq-ac53_e.htm]

Flannigan, M. D., K. A. Logan, B. D. Amiro, W. R. Skinner and B. J. Stocks, 2004: Future area burned in Canada. *Clim. Change*, **72**, 1-16.

Fletcher, M., 2004: Blackout sheds light on outage risks; Dark days of 2003 teach lessons. *Business Insurance*, 1-4. May 24, 2004.

Fleury, M.D., D. Charron, J. Holt, B. Allen and A. Maarouf, 2006: The role of ambient temperature in foodborne disease in Canada using time series methods *Int. J. Biometeorol.*, **50**, DOI 10.1007/s00484-00006-00028-00489.

Foley, J.A., R. DeFries, G.P. Asner, C. Barford, G. Bonan, S.R. Carpenter, F.S. Chapin, M.T. Coe, G.C. Daily, H.K. Gibbs, J.H. Helkowski, T. Holloway, E.A. Howard, C.J. Kucharik, C. Monfreda, J.A. Patz, I.C. Prentice, N. Ramankutty and P.K. Snyder, 2005: Global consequences of land use. *Science*, **309**, 570-574.

Fontaine, T.A., J.F. Klassen, T.S. Cruickshank and R.H. Hotchkiss, 2001: Hydrological response to climate change in the Black Hills of South Dakota, USA. *Hydrol. Sci.*, **46**, 27-40.

Forbes, D.L., G.K. Manson, R. Chagnon, S.M. Solomon, J.J. van der Sanden and T.L. Lynds, 2002a: Nearshore ice and climate change in the southern Gulf of St. Lawrence. *Ice in the environment. Proceedings 16th IAHR International Symposium on Ice*, Dunedin, New Zealand, 1, 344-351.

Forbes, D.L., R.W. Shaw and G.K. Manson. 2002b: Adaptation. *Coastal Impacts of Climate Change and Sea-Level Rise on Prince Edward Island*, D.L. Forbes and R.W. Shaw, Eds., Geological Survey of Canada Open File 4261, Supporting Document 11, Natural Resources Canada, Dartmouth, Nova Scotia, 1-18.

Forbes, D.L., G.S. Parkes, G.K. Manson and L.A. Ketch, 2004: Storms and shoreline retreat in the southern Gulf of St. Lawrence. *Marine Geol.*, **210**, 169-204.

Forister, M.L. and A.M. Shapiro, 2003: Climatic trends and advancing spring flight of butterflies in lowland California. *Global Change Biol.*, **9**, 1130-1135.

Fung, I., S.C. Doney, K. Lindsay and J. John, 2005: Evolution of carbon sinks in a changing climate. *Proc. Nati. Acad. Sci.*, **102**, 11201-11206.

Gallagher, P. and L. Wood, 2003: *Proc. The World Summit on Salmon*, June 10-13, 2003, Vancouver, British Columbia [Accessed 09.02.07: www.sfu.ca/cstudies/science/summit.htm]

Gamache, I. and S. Payette, 2004: Height growth response of tree line black spruce to recent climate warming across the forest-tundra of eastern Canada. *J. Ecol.*, **92**, 835-845.

Gamble, J.L., J. Furlow, A.K. Snover, A.F. Hamlet, B.J. Morehouse, H. Hartmann and T. Pagano, 2004: Assessing the Impact of Climate Variability and Change on Regional Water Resources: The Implications for Stakeholders, in Water: Science, Policy, and Management, Lawford, R., D. Fort, H. Hartmannand S. Eden, Eds., Water Resources Monograph Series, Volume 16, American Geophysical Union, Washington, District of Columbia.

Gan, J.B., 2004: Risk and damage of southern pine beetle outbreaks under global climate change. *Forest Ecol. Manag.*, **191**, 61-71.

GAO, 2003: *Freshwater Supply: States' Views of How Federal Agencies Could Help Them Meet the Challenges of Expected Shortages,* GAO-03-514, U.S. Governmental Accountability Office. U.S. Congress, General Accounting Office, Washington, District ofColumbia, 118 pp. [Accessed 09.02.07: http://www.gao.gov/new.items/d03514.pdf]

Gent, J.F., E.W. Triche, T.R. Holford, K. Belanger, M.B. Bracken, W.S. Beckett and B.P. Leaderer, 2003: Association of low-level ozone and fine particles with respiratory symptoms in children with asthma. *JAMA J. Am. Med. Assoc.*, **290**, 1859-1867.

Gerber, S., F. Joos and I. C. Prentice, 2004: Sensitivity of a dynamic global vegetation model to climate and atmospheric $CO_2$. *Global Change Biol.*, **10**, 1223-1239.

Gibbs, J.P. and A.R. Breisch, 2001: Climate warming and calling phenology of frogs near Ithaca, New York, 1900-1999. *Conserv. Biol.*, **15**, 1175-1178.

Gillett, N.P., A.J. Weaver, F.W. Zwiers and M.D. Flannigan, 2004: Detecting the effect of climate change on Canadian forest fires. *Geophys. Res. Lett.*, **31**, doi:10.1029/2004GL020876.

Goklany, I., 2000: *Applying the precautionary principle to genetically modified crops,* Centre for the Study of American Business, Washington University, St. Louis, Missouri.

Goklany, I., 2001: Precaution without perversity: A comprehensive application of the precautionary principle to genetically modified crops. *Biotechnol. Law Rep.*, **20**, 377-396.

Goklany, I. M., 2006: Death and Death Rates Due to Extreme Weather Events: Global and U.S. Trends, 1900-2004. *Climate Change and Disaster Losses: Understanding and Attributing Trends and Projections*, Workshop Report, 25-26 May 2006, Hohenkammer, Germany. 103-117.

Goklany, I., 2007: Integrated strategies to reduce vulnerability and advance adaptation, mitigation and sustainable development. Mitigat. Adapt. Strat. Glob. Change, doi 10.1007/s11027-007-9098-1.

Goodwin, B.K., 2003: Does risk matter? Discussion. *Amer. J. Agric. Econ.*, **85**, 1257-1258.[Global; agriculture]

Gooseff, M.N., K. Strzepek and S.C. Chapra, 2005: Modeling the potential effects of climate change on water temperature downstream of a shallow reservoir, lower Madison River, MT. *Clim. Change*, **68**, 331-353.

Gornitz, V. and S. Couch. 2001: Sea level rise and coastal. *Climate Change and a Global City: The Potential Consequences of Climate Variability and Change*, C. Rosenzweig and W.D. Solecki, Eds., Columbia Earth Institute, New York, New York.

Gornitz, V., S. Couch and E.K. Hartig, 2001: Impacts of sea level rise in the New York City metropolitan area. *Glob. Planetary Change*, **32**, 61-88.

Gray, K.N., 1999: *The impacts of drought on Yakima Valley irrigated agriculture and Seattle municipal and industrial water supply*. Masters Thesis, University of Washington, Seattle, Washington, 102 pp.

Groisman, P.Y., R.W. Knight, T.R. Karl, D.R. Easterling, B. Sun and J.H. Lawrimore, 2004: Contemporary changes of the hydrological cycle over the contiguous United States: trends derived from *in situ* observations. *J. Hydrometeorol.*, **5**, 64-85.

Guenther, A., 2002: The contribution of reactive carbon emissions from vegetation to the carbon balance of terrestrial ecosystems. *Chemosphere*, **49**, 837-844.

Gunn, J.M., 2002: Impact of the 1998 El Nino event on a lake charr, *Salvelinus namaycush*, population recovering from acidification. *Environ. Biol. Fishes*, **64**, 343-351.

Guy Carpenter, 2006: *The Catastrophe Bond Market at Year-End 2005,* Guy Carpenter & Company, New York, New York, 24 pp. [Accessed 09.02.07: http://www.guycarp.com/portal/extranet/pdf/GCPub/CatBond_yr_end05.pdf;jsessionid=GZzYQcdnb8ndTQ1P2zG1y7p1HqhTgD0LSzfsTQF15HnGyWDY0FXh!1582131896?vid=1]

Hadley, S.W., D.J. Erickson, III, J.L. Hernandez, C.T. Broniak and T.J. Blasing, 2006: Responses of energy use to climate change: A climate modeling study. *Geophys. Res. Lett.*, **33**, doi:10.1029/2006GL026652.

Hamlet, A.F. 2003: The role of the transboundary agreements in the Columbia River Basin: An integrated assessment in the context of historic development, climate and evolving water policy. *Climate and Water: Transboundary Challenges in the Americas*, H. Diaz and B. Morehouse, Eds., Kluwer, Dordrecht, 263-289.

Hamlet, A. and D. Lettenmaier, 1999: Effects of climate change on hydrology and water resources in the Columbia River Basin. *J. Amer. Water Resour. Assoc.*, **35**, 1597-1623.

Hamlet, A.F., D. Huppert and D.P. Lettenmaier, 2002: Value of long-lead streamflow forecasts for Columbia River hydropower. *J. Water Resour. Plan. Manag. - ASCE*, **128**, 91-101.

Hanesiak, J.M. and X.L.L. Wang, 2005: Adverse-weather trends in the Canadian Arctic. *J. Climate*, **18**, 3140-3156.

Hansen, J.E., R. Ruedy, M. Sato, M. Imhoff, W. Lawrence, D. Easterling, T. Peterson and T. Karl, 2001: A closer look at United States and global surface temperature change. *J. Geophys. Res.*, **106**, 23947-23963.

Hansler, G. and D.C. Major. 1999: Climate change and the water supply systems of New York City and the Delaware Basin: Planning and action considerations for water managers. *Proc. of the Specialty Conference on Potential Consequences of Climate Variability and Change to Water Resources of the United States*, D. Briane Adams, Ed., American Water Resources Association, Herndon, Virginia, 327-330.

Hansom, J.D., 2001: Coastal sensitivity to environmental change: A view from the beach. *Catena*, **42**, 291-305.

Hatfield, J.L. and J.H. Pruger, 2004: Impacts of changing precipitation patterns on water quality. *J. Soil Water Conserv.*, **59**, 51-58.

Hayhoe, K., D. Cayan, C. Field, P. Frumhoff, E. Maurer, N. Miller, S. Moser, S. Schneider, K. Cahill, E. Cleland, L. Dale, R. Drapek, R.M. Hanemann, L. Kalkstein, J. Lenihan, C. Lunch, R. Neilson, S. Sheridan and J. Verville, 2004: Emissions pathways, climate change, and impacts on California. *Proc. Nat. Acad. Sci.*, **101**, 12422–12427.

Heinz Center, 2000: *The Hidden Costs of Coastal Hazards: Implications for Risk Assessment and Mitigation*. The H. John Heinz III Center for Science, Economics and the Environment, Island Press, Washington, District of Columbia, 220 pp.

Hengeveld, H., B. Whitewood and A. Fergusson, 2005: *An Introduction to Climate Change: A Canadian Perspective*. Environment Canada, Downsview, Ontario, 55 pp.

Hersteinsson, P. and D.W. Macdonald, 1992: Interspecific competition and the geographical distribution of red and arctic foxes, *Vulpes vulpes* and *Alopex lagopus*. *Oikos*, **64**, 505-515.

Hicke, J.A. and D.B. Lobell, 2004: Spatiotemporal patterns of cropland area and net primary production in the central United States estimated from USDA agricultural information. *Geophys. Res. Lett.*, **31**, doi: 10.1029/2004GL020927.

Hicke, J.A., G.P. Asner, J.T. Randerson, C.J. Tucker, S.O. Los, R.A. Birdsey, J.C. Jenkins, C. Field and E. Holland, 2002: Satellite-derived increases in net primary productivity across North America 1982-1998. *Geophysical Research Letters*, **29**, doi:10.1029/2001GL013578.

Hill, D. and R. Goldberg, 2001: Energy demand. *Climate Change and a Global City: The Potential Consequences of Climate Variability and Change*, C. Rosenzweig and W.D. Solecki, Eds., Columbia Earth Institute, New York, New York [Accessed 09.02.07: http://metroeast_climate.ciesin.columbia.edu/energy.html]

Hogg, E.H., J.P. Brandt and B. Kochtubajda, 2002: Growth and dieback of aspen forests in northwestern Alberta, Canada in relation to climate and insects. *Can. J. For. Res.*, **32**, 823-832.

Hogrefe, C., B. Lynn, K. Civerolo, J. Rosenthal, C. Rosenzweig, R. Goldberg, S. Gaffin, K. Knowlton and P.L. Kinney, 2004: Simulating changes in regional air pollution over the eastern United States due to changes in global and regional climate and emissions. *J. Geophys. Res.*, **109**, doi:10.1029/2004JD004690.

Hostetler, S. and E. Small, 1999: Response of both American freshwater lakes to simulated future climates. *J. Amer. Water Resour. Assoc.*, **35**, 1625-1637.

Houser, S., V. Teller, M. MacCracken, R. Gough and P. Spears. 2001: Chapter 12: Potential consequences of climate variability and change for native peoples and homelands. *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change, Report for the US Global Change Research Program*, U.S. National Assessment Synthesis Team, Ed. Cambridge University Press, Cambridge,351-377. [Accessed 09.02.07: http://www.usgcrp.gov/usgcrp/Library/nationalassessment/foundation.htm]

Howard, J.A., 2000: *National Association of Insurance Commissioners Roundtable Meeting*, National Flood Insurance Program, Washington, District of Columbia. [Accessed 09.02.07: http://permanent.access.gpo.gov/lps18804/www.fema.gov/nfip/jahsp13.htm]

Hunt, M., 2005: *Flood Reduction Master Plan*. Presented to the City of Peterborough City Council, Peterborough, Ontario, Canada.

Hutton, D., 2001: *Psychosocial Aspects of Disaster Recovery: Integrating Communities into Disaster Planning and Policy Making*. Institute for Catastrophic Loss Reduction, Toronto, Ontario, 16 pp.

Ikeme, J., 2003: Equity, environmental justice and sustainability: Incomplete approaches in climate change politics. *Global Environ. Change*, **13**, 195-206.

Industry Canada, 2006: *Canada Industry Statistics: Gross Domestic Product (GDP): Transportation and Warehousing (NAICS 48-49)*. Industry Canada, Ottawa, Canada. [Accessed 12.02.07: http://strategis.ic.gc.ca/ canadian_industry_statistics/cis.nsf/IDE/cis48-49gdpe.html]

Instanes, A., O. Anisimov, L. Brigham, D. Goering, L.N. Khrustalev, B. Ladanyi and J.O. Larsen, 2005: Infrastructure: buildings, support systems, and industrial facilities. *Arctic Climate Impact Assessment, ACIA*, Cambridge University Press, New York, 907-944.

ISMA, 2006: *Facts and Figures about Snowmobiling*. International Snowmobile Manufacturers Association. [Accessed 12.02.07: http://www.ccso-ccom.ca/contente.htm]

ISRP/ISAB, 2004: Scientific Review of Subbasin Plans for the Columbia River Basin Fish and Wildlife Program. Independent Scientific Review Panel for the Northwest Power and Conservation Council; and Independent Scientific Advisory Board for the Council, Columbia River Basin Indian Tribes, and NOAA Fisheries, 152 pp. [Accessed 12.02.07: http://www.nwppc.org/library/ isrp/isrpisab2004-13.pdf]

Izaurralde, R.C., N.J. Rosenberg, A.M. Thomson and R.A. Brown, 2005: Climate change impacts for the conterminous USA: An integrated assessment. Part 6: Distribution and productivity of unmanaged ecosystems. *Clim. Change*, **69**, 107-126.

Jackson, D.A. and N.E. Mandrak, 2002: Changing fish biodiversity: Predicting the loss of cyprinid biodiversity due to global climate change. *Sea Grant Symposium on Fisheries in a Changing Climate; August 20-21, 2001; Phoenix, AZ, USA*, N.A. McGinn, Ed., American Fisheries Society, Bethesda, Maryland, 89-98.

Jacob, K.H., N. Edelblum and J. Arnold, 2001: Infrastructure. *Climate Change and a Global City: The Potential Consequences of Climate Variability and Change*, C. Rosenzweig and W.D. Solecki, Eds., Columbia Earth Institute, New York, New York, 45-76. [Accessed 12.02.07: http://metroeast_climate.ciesin.columbia.edu/reports/infrastructure.pdf]

Jansen, W. and R.H. Hesslein, 2004: Potential effects of climate warming on fish habitats in temperate zone lakes with special reference to Lake 239 of the experimental lakes area (ELA), north-western Ontario. *Environ. Biol.Fishes*, **70**, 1-22.

Jha, M., Z.T. Pan, E.S. Takle and R. Gu, 2004: Impacts of climate change on streamflow in the Upper Mississippi River Basin: A regional climate model perspective. *J. Geophys. Res.*, **109**, D09105.

Johnstone, J.F. and F.S. Chapin, III, 2003: Non-equilibrium succession dynamics indicate continued northern migration of Lodgepole Pine. *Global Change Biol.*, **9**, 1401-1409.

Jones, B. and D. Scott, 2006: Climate Change, Seasonality and Visitation to Canada's National Parks. *J. Parks Recreation Admin.*, **24**, 42-62.

Jones, M.L., B.J. Shuter, Y.M. Zhao and J.D. Stockwell, 2006: Forecasting effects of climate change on Great Lakes fisheries: models that link habitat supply to population dynamics can help. *Can. J. Fish. Aquat. Sci.*, **63**, 457-468.

Joos, F., I.C. Prentice and J.I. House, 2002: Growth enhancement due to global atmospheric change as predicted by terrestrial ecosystem models: Consistent with US forest inventory data. *Global Change Biol.*, **8**, 299-303.

Kalkstein, L.S., 2002: Description of our heat/health watch-warning systems: their nature and extent, and required resources. Center for Climatic Research, University of Delaware, Newark, Delaware, 31 pp.

Kamler, E., 2002: Ontogeny of yolk-feeding fish: An ecological perspective. *Rev. Fish Biol. Fish.*, **12**, 79-103.

Karl, T., R. Knight, D. Easterling and R. Quayle, 1996: Indices of climate change for the United States. *Bull. Amer. Meteor. Soc.*, **77**, 279-292.

Karl, T., J. Lawrimore and A. Leetma, 2005: Observational and modeling evidence of climate change. *EM, A&WMA's magazine for environmental managers*, **October 2005**, 11-17.

Karnosky, D.F., K.S. Pregitzer, D.R. Zak, M.E. Kubiske, G.R. Hendrey, D. Weinstein, M. Nosal and K.E. Percy, 2005: Scaling ozone responses of forest trees to the ecosystem level in a changing climate. *Plant Cell Environ.*, **28**, 965-981.

Karoly, D.J., K. Braganza, P.A. Stott, J.M. Arblaster, G.A. Meehl, A.J. Broccoli and K.W. Dixon, 2003: Detection of a human influence on North American climate. *Science*, **302**, 1200-1203.

Kasischke, E.S. and M.R. Turetsky, 2006: Recent changes in the fire regime across the North American boreal region-Spatial and temporal patterns of burning across Canada and Alaska. *Geophys. Res. Lett.*, **33** doi:10.1029/2006GL 025677,022006.

Kennish, M.J., 2001: Coastal salt marsh systems in the US: a review of anthropogenic impacts. *J. Coastal Res.*, **17**, 731-748.

Kennish, M.J., 2002: Environmental threats and environmental future of estuaries. *Environ. Conserv.*, **29**, 78-107.

Kesmodel, D., 2002: Low and dry: Drought chokes off Durango rafting business. *Rocky Mountain News*, **25 June 2002**.

Kiesecker, J.M., A.R. Blaustein and L.K. Belden, 2001: Complex causes of amphibian population declines. *Nature*, **410**, 681-683.

Kije Sipi Ltd., 2001: *Impacts and adaptation of drainage systems, design methods and policies: impacts and adaptation contribution agreement A330*. Natural Resources Canada, Climate Change Action Fund, 117 pp. [Accessed 12.02.07: http://adaptation.nrcan.gc.ca/projdb/pdf/43_e.pdf]

Kim, J., T.K. Kim, R.W. Arritt and N.L. Miller, 2002: Impacts of increased $CO_2$ on the hydroclimate of the western United States. *J. Climate*, **15**, 1926-1942.

Kim, Q.S., 2004: Industry Aims to Make Homes Disaster-Proof. *Wall Street Journal*, **30** September2004.

Kinney, P.L., D. Shindell, E. Chae and B. Winston, 2001: Public health. *Climate Change and a Global City: The Potential Consequences of Climate Variability and Change*, C. Rosenzweig and W.D. Solecki, Eds., Columbia Earth Institute, New York, New York, 103-120. [Accessed 12.02.07: http://metroeast_climate.ciesin.co-

lumbia.edu/reports/health.pdf]

Kirshen, P.H., 2002: Potential impacts of global warming on groundwater in eastern Massachusetts. *J. Water Resour. Plan. Manag.*, **128**, 216-226.

Swetnam, T., T.W. Swetnam and T.T. Veblen, 2001: Inter-hemispheric synchrony of forest fires and the El Nino-Southern Oscillation. *Global Ecol. Biogeogr.*, **10**, 315-326.

Kleinosky, L.R., B. Yarnal and A. Fisher, 2006: Vulnerability of Hampton Roads, Virginia, to storm-surge flooding and sea-level rise. *Natural Hazards*, **39**, doi: 10.1007/s11069-11006-10004-z.

Knowles, N., M.D. Dettinger and D.R. Cayan, 2006: Trends in snowfall versus rainfall for the western United States, 1949-2004. *J. Climate*, **19**, 4545-4559.

Knowlton, K., J.E. Rosenthal, C. Hogrefe, B. Lynn, S. Gaffin, R. Goldberg, C. Rosenzweig, K. Civerolo, J-Y Ku and P.L. Kinney, 2004: Assessing ozone-related health impacts under a changing climate. *Environ. Health Perspect.*, **112**, 1557-1563.

Kolivras, K.N. and A.C. Comrie, 2003: Modeling valley fever (coccidioidomycosis) incidence on the basis of climate conditions. *Int. J. Biometeorol.*, **47**, 87-101.

Komar, P.D., J. Allan, G.M. Dias-Mendez, J.J. Marra and P. Ruggiero, 2000: El Niño and La Niña: erosion processes and impacts. *Proc. of the 27th International Conference on Coastal Engineering*, ASCE, Sydney, Australia, 2414-2427.

Koppe, C., S. Kovats, G. Jendritzky and B. Menne, 2004: *Heat-waves: Risks and Responses*, World Health Organization, Europe, Copenhagen, 124 pp. [Accessed 12.02.07: http://www.euro.who.int/document/E82629.pdf]

Koshida, G., M. Alden, S.J. Cohen, R. Halliday, L.D. Mortsch, V. Wittrock and A.R. Maarouf, 2005: Drought risk management in Canada-U.S. Transboundary watersheds: now and in the future. *Drought and Water Crisis - Science, Technology and Management Issues*, D. Wilhite, Ed., CRC Press, Boca Raton, Florida, 287-319.

Kovacs, P., 2005a: *Canadian Underwriter: Homeowners and Natural Hazards*, Jan 1, 2005, Institute for Catastrophic Loss Reduction, Toronto, Ontario, 5 pp.

Kovacs, P., 2005b: Homeowners and natural hazards. *Canadian Underwriter*, January 2005.

Kovacs, P. and H. Kunreuther, 2001: Managing Catastrophic Risk: Lessons from Canada. *Assurance J. Insur. Risk Manag.*, **69**.

Kumagi, Y., J. Edwards and M.S. Carroll, 2006: Why are natural disasters not "natural" for its victims? *Environ. Impact Assess. Rev.*, **26**, 106-119.

Kunkel, K. E., 2003: Temporal variations of extreme precipitation events in the United States: 1895-2000. *Geophys. Res. Lett.*, **30**, doi:10.1029/2003GL018052

Kunkel, K.E., R.A. Pielke Jr. and S.A. Changnon, 1999: Temporal fluctuations in weather and climate extremes that cause economic and human health impacts: A review. *Bull. Amer. Meteor. Soc.*, **80**, 1077-1098.

Kunreuther, H., 2006: Disaster mitigation and insurance: Learning from Katrina. *Ann. Amer. Acad. Polit. Soc. Sci.*, **604**, 208-227.

Kunreuther, H., R. Daniels and D. Kettl, 2006: *On Risk and Disaster: Lessons from Hurricane Katrina*. University of Pennsylvania Press, Philadelphia, 304 pp.

Kutzbach, J.E., J.W. Williams and S.J. Vavrus, 2005: Simulated 21st century changes in regional water balance of the Great Lakes region and links to changes in global temperature and poleward moisture transport. *Geophys. Res. Lett.*, **32**, doi:10.1029/2005GL023506.

LaCommare, K.H. and J.H. Eto, 2004: *Understanding the cost of power interruptions to U.S. electricity consumers*. LBNL-55718, Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, California, 70 pp. [Accessed 12.02.07: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=2531&context=lbnl]

Leatherman, S.P., 2001: Social and environmental costs of sea level rise. *Sea Level Rise, History and Consequences*, B.C. Douglas, M.S. Kearney and S.P. Leatherman, Eds., Academic Press, San Diego, California, 181-223.

Lebel, L., 2004: Social change and $CO_2$ stabilization: Moving away from carbon cultures. *The Global Carbon Cycle: Integrating Humans, Climate, and the Natural World*, C.B. Field and M.R. Raupach, Eds., Island Press, Washington, District of Columbia, 371-382.

Lehman, J., 2002: Mixing patterns and plankton biomass of the St. Lawrence Great Lakes under climate change scenarios. *J. Great Lakes Res.*, **28**, 583-596.

Leiss, W., 2001: *In the Chamber of Risks: Understanding Risk Controversies*. McGill-Queen's University Press, Montreal, Quebec,388 pp.

Lemke, P., J. Ren, R. Alley, I. Allison, J. Carrasco, G. Flato, Y. Fuji, G. Kaser, P. Mote, R.H. Thomas and T. Zhang, 2007: Observations: changes in snow, ice and frozen ground. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Eds., Cambridge University Press, Cambridge and New York, 337-384.

Lemmen, D.S. and F.J. Warren, Eds., 2004: *Climate Change Impacts and Adaptation: A Canadian Perspective*. Climate Change Impacts and Adaptation Directorate, Natural Resources Canada Ottawa, Ontario, 201 pp. [Accessed 12.02.07: http://environment.msu.edu/climatechange/canadaadaptation.pdf]

Lerdau, M. and M. Keller, 1998: Controls on isoprene emission from trees in a subtropical dry forest. *Plant, Cell Environ.*, **20**, 569-579.

Lester, N.P., A.J. Dextrase, R.S. Kushneriuk, M.R. Rawson and P.A. Ryan, 2004: Light and temperature: Key factors affecting walleye abundance and production. *Trans. Amer. Fish. Soc.*, **133**, 588-605.

Lettenmaier, D.P. and A.F. Hamlet. 2003: Improving Water Resources System Performance Through Long-Range Climate Forecasts: the Pacific Northwest Experience. *Water and Climate in the Western United States*, W.M. Lewis Jr., Ed., University Press of Colorado, Boulder, Colorado.

Lettre, J., 2000: Weather Risk Management Solutions, Weather Insurance, Weather Derivatives. Research Paper, Financial Management, 30 November 2000, Rivier College, Nashua, New Hampshire. [Accessed 12.02.07: http://hometown.aol.com/gml1000/wrms.htm]

Leung, L.R. and Y. Qian, 2003: Changes in seasonal and extreme hydrologic conditions of the Georgia Basin/Puget Sound in an ensemble regional climate simulation for the mid–Century. *Can. Water Resour. J.*, **28**, 605-632.

Levitan and Associates Inc., 2005: Post Katrina and Rita outlook on fuel supply adequacy and bulk power security in New England, Levitan and Associates, Inc, Boston, Massachusetts, 9 pp. [Accessed 12.02.07: http://www.islandereastpipeline.com/articles/post_hurricane_outlook.pdf]

Lewis, E.J., 1987: Survey of residential air-to-air heat pump service and life and maintenance issues. *ASHRAE Transactions*, **93**(1), 1111-1127.

Ligeti, E., 2006: *Adaptation strategies to reduce health risks from summer heat in Toronto*. Toronto Atmospheric Fund, Toronto, Canada.

Loáiciga, H.A., 2000: Climate change impacts in regional-scale aquifers: principles and field application. In: *Groundwater Updates*. Sato, K. and Y. Iwasa, Eds. Springer, Tokyo, Japan, 247-252.

Loáiciga, H.A., D.R. Maidment and J.B. Valdes, 2000: Climate-change impacts in a regional karst aquifer, Texas USA. *J. Hydrology*, **227**, 173-194.

Lobell, D.B. and P. Asner, 2003: Climate and management contributions to recent trends in U.S. agricultural yields. *Science*, **299**, 1032.

Lobell, D.B., J.A. Hicke, G.P. Asner, C.B. Field, C.J. Tucker and S.O. Los, 2002: Satellite estimates of productivity and light use efficiency in United States agriculture, 1982-98. *Glob. Change Biol.*, **8**, 722-735.

Lobell, D.B., K.N. Cahill and C.B. Field, 2006: Historical effects of temperature and precipitation on California crop yields. *Clim. Change*, **81**, 187-203.

Loehle, C., J.G. MacCracken, D. Runde and L. Hicks, 2002: Forest management at landscape scales: solving the problems. *J. Forestry*, **100**, 25-33.

Lofgren, B.M., F.H. Quinn, A.H. Clites, R.A. Assel, A.J. Eberhardt and C.L. Luukkonen, 2002: Evaluation of potential impacts on Great Lakes water resources based on climate scenarios of two GCMs. *J. Great Lakes Res.*, **28**, 537-554.

Logan, J.A., J. Regniere and J.A. Powell, 2003: Assessing the impacts of global warming on forest pest dynamics. *Front. Ecol. Environ.*, **1**, 130-137.

Lonergan, S., R. DiFrancesco and M. Woo, 1993: Climate change and transportation in northern Canada: An integrated impact assessment. *Clim. Change*, **24**, 331-351.

Long, S.P., E.A. Ainsworth, A.D.B. Leakey and P.B. Morgan, 2005: Global food insecurity. Treatment of major food crops with elevated carbon dioxide or ozone under large-scale fully open-air conditions suggests recent models may have overestimated future yields. *Phil. Trans. Royal Soc. Lond. B Biol. Sci.*, **360**, 2011-2020.

Loukas, A., L. Vasiliades and N.R. Dalezios, 2002: Potential climate change impacts on flood producing mechanisms in southern British Columbia, Canada using the CGCMA1 simulation results. *J. Hydrol.*, **259**, 163-188.

Lucht, W., I.C. Prentice, R.B. Myneni, S. Sitch, P. Friedlingstein, W. Cramer, P. Bousquet, W. Buermann and B. Smith, 2002: Climate control of the high-latitude vegetation greening trend and Pinatubo effect. *Science*, **296**, 1687-1689.

Magnuson, J.J., D.M. Robertson, B.J. Benson, R.H. Wynne, D.M. Livingstone, T. Arai, R.A. Assel, R.G. Barry, V. Card, E. Kuusisto, N.C. Granin, T.D. Prowse, K.M. Stewart and V.S. Vuglinski, 2000: Historical trends in lake and river ice cover in the Northern Hemisphere. *Science*, **289**, 1743-1746.

Major, D. and R. Goldberg, 2001: Water supply. *Climate Change and a Global City: The Potential Consequences of Climate Variability and Change*, C. Rosenzweig and W. D. Solecki, Eds., Columbia Earth Institute, New York, New York, 87-101. [Accessed 12.02.07: http://metroeast_climate.ciesin.columbia.edu/reports/water.pdf]

McBean, G. and D. Henstra, 2003: *Climate Change, Natural Hazards and Cities*. ICLR Reseach Paper Series No. 31. Institute for Catastrophic Loss Reduction, Toronto, Canada, 18 pp.

McBeath, J., 2003: Institutional responses to climate change: The case of the Alaska transportation system. *Mitigation Adapt. Strategies Global Change*, **8**, 3-28.

McCabe, G.J. and J.E. Bunnell, 2004: Precipitation and the occurrence of Lyme disease in the northeastern United States. *Vector-Borne and Zoonotic Diseases*, **4**, 143-148.

McCabe, G.J., M.P. Clark and M.C. Serreze, 2001: Trends in northern hemisphere surface cyclone frequency and intensity. *J. Climate*, **14**, 2763-2768.

McConnell, R., K. Berhane, F. Gilliland, S.J. London, T. Islam, W.J. Gauderman, W. Avol, H.G. Margolis and J.M. Peters, 2002: Asthma in exercising children exposed to ozone: A cohort study. *The Lancet*, **359**, 386-391.

McGee, T., S. Reinholdt, S. Russell, N. Rogers and L. Boxelar, 2000: Effective Behaviour Change Programs for Natural Hazard Reduction in Rural Communities, Final Report, IDNDR Project 7/99.

McKenzie, D., A.E. Hessl and D.L. Peterson, 2001: Recent growth of conifer species of western North America: Assessing spatial patterns of radial growth trends. *Can. J. For. Res.*, **31**, 526-538.

McKenzie, D., Z. Gedalof, D.L. Peterson and P. Mote, 2004: Climatic change, wildfire and conservation. *Conserv. Biol.*, **18**, 890-902.

Mearns, L.O., G. Carbone, R.M. Doherty, E.A. Tsvetsinskaya, B.A. McCarl, R.M. Adams and L. McDaniel, 2003: The uncertainty due to spatial scale of climate scenarios in integrated assessments: An example from U.S. agriculture. *Integrated Assessment*, **4**, 225-235.

Meehl, G.A. and C. Tebaldi, 2004: More intense, more frequent, and longer lasting heat waves in the 21st century. *Science*, **305**, 994-997.

Meehl, G.A., T.F. Stocker, W.D. Collines, P. Friedlingstein, A.T. Gaye, J.M. Gregory, A. Kitoh, R. Knutti, J.M. Murphy, A. Noda, S.C.B. Raper, I.G. Watterson, A.J. Weaver and Z.-C. Zhao, 2007: Global climate projections. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Eds., Cambridge University Press, Cambridge and New York, 747-846.

Mendelsohn, R., Ed., 2001: *Global Warming and the American Economy: A Regional Assessment of Climate Change Impacts*. Edward Elgar, Northampton, Massachusetts, 209 pp.

Mendelsohn, R. and M.E. Schlesinger, 1999: Climate response functions. *Ambio*, **28**, 362-366.

Mercier, G., 1998: Climate change and variability: Energy sector. *Canada Country Study: Impacts and Adaptations*, G. Koshida and W. Avis, Eds., Kluwer Academic Publishers, Dordrecht.

Merritt, W., Y. Alila, M. Barton, B. Taylor, S. Cohen and D. Neilsen, 2005: Hydrologic response to scenarios of climate change in sub-watersheds of the Okanagan basin, British Columbia. *J. Hydrology*, **326**, 79-108, doi:10.1016/j.jhydrol.2005.1010.1025.

Michel-Kerjan, E., 2006: Insurance, the 14th critical sector. *Seeds of Disaster, Roots of Response: How Private Action Can Reduce Public Vulnerability*, P. Auerswald, L. Branscomb, T.M. La Porte and E. Michel-Kerjan, Eds., Cambridge University Press, New York, 279-291.

Miles, E.L., A.K. Snover, A. Hamlet, B. Callahan and D. Fluharty, 2000: Pacific northwest regional assessment: The impacts of climate variability and climate change on the water resources of the Columbia River Basin. *J. Amer. Water Resour. Assoc.*, **36**, 399-420.

Miller, N.L. 2003: California climate change, hydrologic response, and flood forecasting. *International Expert Meeting on Urban Flood Management*, World Trade Center Rotterdam, The Netherlands, 11pp. [Accessed 12.02.07: http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1454&context=lbnl]

Miller, N.L., K.E. Bashford and E. Strem, 2003: Potential impacts of climate change on California hydrology. *J. Amer. Water Resour. Assoc.*, **39**, 771-784.

Millerd, F., 2005: The economic impact of climate change on Canadian commercial navigation on the Great Lakes. *Can. Water Resour. J.*, **30**, 269-281.

Mills, B., S. Tighe, J. Andrey, K. Huen and S. Parm, 2006: Climate change and the performance of pavement infrastructure in southern Canada, context and case study. *Proc. of the Engineering Institute of Canada (EIC) Climate Change Technology Conference*, May 9-12, 2005, Ottawa.

Mills, E. and E. Lecomte, 2006: From Risk to Opportunity: How Insurers Can Proactively and Profitably Manage Climate Change, CERES, Inc. Report, Boston, Massachusetts, 52 pp.

Mirza, M.M.Q., 2004: Climate Change and the Canadian Energy Sector: Report on Vulnerability and Adaptation, Adaptation and Impacts Research Group, Atmospheric Climate Science Directorate, Meteorological Service of Canada Downsview, Ontario, Canada, 52 pp.

Mohseni, O., H.G. Stefan and J.G. Eaton, 2003: Global warming and potential changes in fish habitat in U.S. streams. *Clim. Change*, **59**, 389-409.

Mooney, H.A., R.N. Mack, J.A. McNeely, L.E. Neville, P.J. Schei and J.K. Waage, Eds., 2005: *Invasive Alien Species*. Island Press, Washington, District of Columbia, 368 pp.

Morehouse, B.J., R.H. Carter and P. Tschakert, 2002: Sensitivity of urban water resources in Phoenix, Tucson, and Sierra Vista, Arizona to severe drought. *Climate Res.*, **21**, 283-297.

Morgan, M.G., L.F. Pitelka and E. Shevliakova, 2001: Elicitation of expert judgments of climate change impacts on forest ecosystems. *Clim. Change*, **49**, 279-307.

Morris, J.T., P.V. Sundareshwar, C.T. Nietch, B. Kjerfve and D.R. Cahoon, 2002: Responses of coastal wetlands to rising sea level. *Ecology*, **83**, 2869-2877.

Morrison, J., M.C. Quick and M.G.G. Foreman, 2002: Climate change in the Fraser River watershed: Flow and temperature projections. *Journal of Hydrology (Amsterdam)*, **263**, 230-244.

Morrison, W.N. and R. Mendelsohn, 1999: The impact of global warming on U.S. energy expenditures. *The Economic Impact of Climate Change on the United States Economy*, R. Mendelsohn and J. Neumann, Eds., Cambridge University Press, New York, 209-236.

Mortsch, L., M. Alden and J. Scheraga, 2003: Climate change and water quality in the Great Lakes Region - risks opportunities and responses, report prepared for the Great Lakes Water Quality Board for the International Joint Commission, 213 pp.

Mortsch, L., H. Hengeveld, M. Lister, B. Lofgren, F. Quinn, M. Silvitzky and L. Wenger, 2000: Climate change impacts on the hydrology of the Great Lakes-St. Lawrence system. *Can. Water Resour. J.*, **25**, 153-179.

Moser, S., 2000: Community responses to coastal erosion: Implications of potential policy changes to the national flood insurance program. *Evaluation of Erosion Hazards*, The H. John Heinz II Center for Science, Economics and the Environment, Washington District of Columbia,, Appendix F. 99 pp. [Accessed 12.02.07: http://www.heinzctr.org/Programs/SOCW/Erosion_ Appendices/ Appendix%20F%20-%20FINAL.pdf]

Moser, S., 2005: *Enhancing Decision-Making through Integrated Climate Research*, Summary of an Exploratory Workshop for the NOAA-OGP-RISA Program, Alaska Regional Meeting, National Oceanic and Atmospheric Administration -Office of Global Programs, 63 pp. [Accessed 12.02.07: http://www.ogp.noaa.gov/mpe/csi/events/risa_021804/report.pdf]

Moser, S., 2006: Impacts assessments and policy responses to sea-level rise in three U.S. States: An exploration of human dimension uncertainties. *Global Environ. Change*, **15**, 353-369.

Moss, R.H., A.L. Breknert and E.L. Malone, 2001: *Vulnerability to Climate Change: A Quantitative Approach*, Pacific Northwest National Laboratory, Richland, Washington.

Mote, P.W., 2003: Trends in snow water equivalent in the Pacific Northwest and their climatic causes. *Geophys. Res. Lett.*, **30**, 3-1.

Mote, P., D. Canning, D. Fluharty, R. Francis, J. Franklin, A. Hamlet, M. Hershman, M. Holmberg, K. Gray-Ideker, W.S. Keeton, D. Lettenmaier, R. Leung, N. Mantua, E. Miles, B. Noble, H. Parandvash, D.W. Peterson, A. Snover and S. Willard, 1999: *Impacts of Climate Variability and Change, Pacific Northwest*, National Atmospheric and Oceanic Administration, Office of Global Programs, and JISAO/SMA Climate Impacts Group, Seattle, Washington, 110 pp. [ Accessed 12.02.07: http://www.usgcrp.gov/usgcrp/nacc/pnw.htm]

Mote, P.W., E.A. Parson, A.F. Hamlet, W.S. Keeton, D. Lettenmaier, N. Mantua, E.L. Miles, D.W. Peterson, D.L. Peterson, R. Slaughter and A.K. Snover, 2003: Preparing for climatic change: the water, salmon, and forests of the Pacific Northwest. *Clim. Change*, **61**, 45-88.

Mote, P., A.F. Hamlet, M.P. Clark and D.P. Lettenmaier, 2005: Declining mountain snowpack in western North America. *Bull. Amer. Meteor. Soc.*, **86**, doi: 10.1175/BAMS-1186-1171-1139.

Moulton, R.J. and D.R. Cuthbert, 2000: Cumulative impacts/risk assessment of water removal or loss from the Great Lakes St. Lawrence River system. *Can. Water Resour. J.*, **25**, 181-208.

Multihazard Mitigation Council, 2005: *An Independent Study to Assess the Future Savings from Mitigation Activities*, National Institute of Building Sciences, Washington, District of Columbia, 377 pp. [Accessed 12.02.07: http://www.nibs.org/MMC/MitigationSavingsReport/natural_hazard_mitigation_saves.htm]

Munich Re., 2004: *Topics: 2004*. GeoRisks Group, Munich Re, Munich, 60 pp.

Muraca, G., D.C. MacIver, H. Auld and N. Urquizo, 2001: The climatology of fog in Canada. *Proc. of the 2nd International Conference on Fog and Fog Collection*, 15-20 July 2005, St. John's, Newfoundland.

Murphy, B., 2004: *Emergency Management and the August 14th, 2003 Blackout*. Institute for Catastrophic Loss Reduction, ICLR Research Paper Series No. 40, Toronto, Canada, 11 pp. [Accessed 12.02.07: http://www.iclr.org/pdf/Emergency 20Preparedness%20and%20the%20blackout2.pdf]

.rphy, B., G. McBean, H. Dolan, L. Falkiner and P. Kovacs, 2005: *Enhancing local level emergency management: the influence of disaster experience and the role of household and neighbourhoods*. Institute for Catastrophic Loss Reduction, ICLR Research Paper Series No. 43, Toronto, Canada, 79 pp.

MWD, 2005: *The Family of Southern California Water Agencies*. Metropolitan Water District of Southern California. [Accessed 12.02.07: http://www.bewaterwise.com/index.html]

Myneni, R.B., J. Dong, C.J. Tucker, P.E. Kaufmann, J. Kauppi, L. Liski, J. Zhou, V. Alexeyev and M.K. Hughes, 2001: A large carbon sink in the woody biomass of northern forests. *Proc. Nat. Acad. Sci.*, **98**, 14784-14789.

Najjar, R.G., H.A. Walker, P.J. Anderson, E.J. Barron, R.J. Bord, J.R. Gibson, V.S. Kennedy, C.G. Knight, J.P. Megonigal, R.E. O'Connor, C.D. Polsky, N.P. Psuty, B.A. Richards, L.G. Sorenson, E.M. Steele and R.S. Swanson, 2000: The potential impacts of climate change on the mid-Atlantic coastal region. *Climate Res.*, **14**, 219-233.

Nakićenović, N. and R. Swart, Eds., 2000: *Special Report on Emissions Scenarios. A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, 599 pp.

NAST, 2000: *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*, Overview Report for the U.S. Global Change Research Program. U.S. National Assessment Synthesis Team, Cambridge University Press, Cambridge, 154 pp. [Accessed 12.02.07: http://www.usgcrp.gov/usgcrp/Library/nationalassessment/overview.htm]

NAST, 2001: *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*, Foundation Report for the US Global Change Research Program. U.S. National Assessment Synthesis Team, Cambridge University Press, Cambridge, 620 pp. [Accessed 12.02.07: http://www.usgcrp.gov/usgcrp/Library/nationalassessment/foundation.htm]

National Voluntary Organizations Active in Disaster, 2006. [Accessed 12.02.07: www.nvoad.org]

ral Resources Canada, 2000: *Canada's National Implementation Strategy on Cli- ..ate Change*. Government of Canada, Ottawa, Canada, 44 pp. [Accessed 12.02.07: http://www.iigr.ca/pdf/documents/1063_Canadas_National_Implem.pdf]

Nearing, M.A., F.F. Pruski and M.R. O'Neal, 2004: Expected climate change impacts on soil erosion rates: a review. *J. Soil Water Conserv.*, **59**, 43-50.

Nelson, E., O.A. Anisimov and N.I. Shiklomanov, 2002: Climate change and hazard zonation in the circum-Arctic permafrost regions. *Nat. Hazards*, **26**, 203-225.

Nemani, R.R., M.A. White, D.R. Cayan, G.V. Jones, S.W. Running, J.C. Coughlan and D.L. Peterson, 2001: Asymmetric warming over coastal California and its impact on the premium wine industry. *Climate Res.*, **19**, 25-34.

Nemani, R.R., M.A. White, P.E. Thornton, K. Nishida, S. Reddy, J. Jenkins and S.W. Running, 2002: Recent trends in hydrologic balance have enhanced the terrestrial carbon sink in the United States. *Geophys. Res. Lett.*, **29**, doi: 10.1029/2002GL014867.

Nicholls, K.H., 1999: Effects of temperature and other factors on summer phosphorus in the inner Bay of Quinte, Lake Ontario: Implications for climate warming. *J. Great Lakes Res.*, **25**, 250-262.

Nordhaus, W.D., 2006: The Economics of Hurricanes in the United States. *Annual Meetings of the American Economic Association*, January 5-8, 2006, American Economic Association, Boston, Massachusetts. [Accessed 12.02.07: http://www.econ.yale.edu/~nordhaus/homepage/hurr_010306a.pdf]

NRC, 2004: *Thinking Strategically: The Appropriate use of Metrics for the Climate Change Science Program*. U.S. National Research Council - Committee on Metrics for Global Climate Change, Climate Research Committee, National Academy Press, Washington District of Columbia, 162 pp. [Accessed 12.02.07: http://books.nap.edu/catalog/11292.html]

O'Neal, K., 2002: *Effects of Global Warming on Trout and Salmon in U.S. Streams*. Defenders of Wildlife, Washington, District of Columbia, 46 pp. [Accessed 12.02.07: http://www.defenders.org/publications/fishreport.pdf]

O'Reilly, C.T., D.L. Forbes and G.S. Parkes, 2005: Defining and adapting to coastal hazards in Atlantic Canada: Facing the challenge of rising sea levels, storm surges, shoreline erosion in a changing climate. *Ocean Yearbook*, **19**, 189-207.

Ogden, N.H., L.R. Lindsay, G. Beauchamp, D. Charron, A. Maarouf, C.J. O'Callagjan, D. Waltner-Toews and I.K. Barker, 2004: Investigation of the relationships between temperature and developmental rates of tick *Ixodes Scapularis* (Acari: Ixodidae) in the laboratory and field. *J. Med. Entomol.*, **41**, 622-633.

Ogden, N.H., A. Maarouf, I.K. Barker, M. Bigras-Poulin, L.R. Lindsay, M.G. Morshed, C.J. O'Callaghan, F. Ramay, D. Waltner-Toews and D.F. Charron, 2006: Climate change and the potential for range expansion of the Lyme disease vector *Ixodes scapularis* in Canada. *Int J Parasitol*, **36**, 63-70.

Ouranos, 2004: *Adapting to Climate Change*. Ouranos, Montreal, Canada. 91 pp. [Accessed 12.02.07: http://www.ouranos.ca/cc/climang5.pdf]

Paavola, J. and W. Adger, 2002: *Justice and Adaptation to Climate Change*. Tyndall Centre for Climate Change Research, Working Paper 23, Norwich, Norfolk, 24 pp. [Accessed 12.02.07: www.tyndall.ac.uk/publications/ working_papers/ wp23.pdf]

Pan, Z.T., M. Segal, R.W. Arritt and E.S. Takle, 2004: On the potential change in solar radiation over the US due to increases of atmospheric greenhouse gases. *Renew. Energ.*, **29**, 1923-1928.

Parmesan, C., 1996: Climate and species range. *Nature*, **382**, 765-766.

Parmesan, C. and G. Yohe, 2003: A globally coherent fingerprint of climate change impacts across natural systems. *Nature*, **421**, 37-42.

Parmesan, C. and H. Galbraith, 2004: *Observed Impacts of Global Climate Change in the U.S.*, Pew Center on Global Climate Change, Arlington, Virginia, 67 pp. [Accessed 12.02.07: http://www.pewclimate.org/global-warming-in-depth/all_reports/observedimpacts/index.cfm.

Parson, E.A., L. Carter, P. Anderson, B. Wang and G. Weller, 2001a: Potential consequences of climate variability and change for Alaska. *Climate Change Impacts on the United States*, National Assessment Synthesis Team, Ed., Cambridge University Press, Cambridge, 283-312.

Parson, E.A., P.W. Mote, A. Hamlet, N. Mantua, A. Snover, W. Keeton, E. Miles, D. Canning and K.G. Ideker, 2001b: Potential consequences of climate variability and change for the Pacific Northwest. *Climate Change Impacts on the United States - The Potential Consequences of Climate Variability and Change-Foundation Report*, National Assessment Synthesis Team, Ed., Cambridge University Press, Cambridge, 247-280.

Parson, E.A., R.W. Corell, E.J. Barron, V. Burkett, A. Janetos, L. Joyce, T.R. Karl, M. MacCracken, J. Melillo, M.G. Morgan, D.S. Schimel and T. Wilbanks, 2003: Understanding climatic impacts, vulnerabilities and adaptation in the United States: Building a capacity for assessment. *Clim. Change*, **57**, 9-42.

Patz, J.A., D. Campbell-Lendrum, T. Holloway and J.A. Foley, 2005: Impact of regional climate change on human health. *Nature*, **438**, 310-317.

Payne, J.T., A.W. Wood, A.F. Hamlet, R.N. Palmer and D.P. Lettenmaier, 2004: Mitigating the effects of climate change on the water resources of the Columbia River basin. *Clim. Change*, **62**, 233-256.

Perez-Garcia, J., L.A. Joyce, A.D. McGuire and X.M. Xiao, 2002: Impacts of climate change on the global forest sector. *Clim. Change*, **54**, 439-461.

Peterson, D.W. and D.L. Peterson, 2001: Mountain hemlock growth trends to climatic variability at annual and decadal time scales. *Ecology*, **82**, 3330-3345.

Peterson, D.W., D.L. Peterson and G.J. Ettl, 2002: Growth responses of subalpine fir to climatic variability in the Pacific Northwest. *Can. J. For. Res.*, **32**, 1503-1517.

Peterson, J.T. and T.J. Kwak, 1999: Modeling the effects of land use and climate change on riverine smallmouth bass. *Ecol. Appl.*, **9**, 1391-1404.

Pielke Jr., R.A., 2005: Attribution of disaster losses. *Science*, **310**, 1615.

Pielke, R. A. and C. W. Landsea, 1998: Normalized hurricane damages in the United States: 1925-95. *Weather and Forecasting*, **13**, 621-631. with extensions through 2005 at http://www.aoml.noaa.gov/hrd/tcfaq/E21.html.

Pielke Jr., R.A. and C.W. Landsea, 1999: La Niña, El Niño, and Atlantic hurricane damages in the United States. *Bull. Amer. Meteorol. Soc.*, **80**, 2027-2033.

Pielke, Jr., R.A., S. Agrawala, L.M. Bouwer, I. Burton, S. Changnon, M.H. Glantz, W.H. Hooke, R.J.T. Klein, K. Kunkel, D. Mileti, D. Sarewitz, E. M. Thompkins, N. Stehr and H. von Storch, 2005. "Clarifying the Attribution of Recent Weather Disaster Losses: A Response to Epstein and McCarthy." *Bull. Am. Meteorol. Soc.*, 86, 1481-1483.

Piggott, A., D. Brown, S. Moin and B. Mills, 2003: Estimating the impacts of climate change on groundwater conditions in western southern Ontario. *Proc. of the 56th Canadian Geotechnical and 4th Joint IAH-CNC and CGS Groundwater Specialty Conferences*. Winnipeg, Canada. Canadian Geotechnical Society and Canadian National Chapter of the International Association of Hydrogeologists, 7 pp.

Pisano, P., L. Goodwin and A. Stern, 2002: Surface transportation safety and operations: The impacts of weather within the context of climate change. *The Potential Impacts of Climate Change on Transportation: Workshop Summary and Proceedings*, Washington, District of Columbia, 20 pp. [Accessed 12.02.07: http://climate.volpe.dot.gov/workshop1002/pisano.pdf]

POL, 2006: *Permanent Service for Mean Sea Level (PSMSL)*. Proudman Oceanographic Laboratory, Liverpool, UK. [Accessed: 12.02.07: http://www.pol.ac.uk/ psmsl/psmsl_individual_stations.html]

Polsky, C. and W.E. Easterling, III, 2001: Adaptation to climate variability and change in the US Great Plains: A multi-scale analysis of Ricardian climate sensitivities. *Agr. Ecosyst. Environ.*, **85**, 133-144.

Polsky, C., D. Schröter, A. Patt, S. Gaffin, M.L. Martello, R. Neff, A. Pulsipher and H. Selin, 2003: *Assessing Vulnerabilities to the Effects of Global Change: An Eight-Step Approach,* 2003-05, Belfer Center for Science & International Affairs, Harvard University, Cambridge, Massachusetts,31 pp. [Accessed 12.02.07: http://www.bcsia.ksg.harvard.edu/BCSIA_content/documents/2003-05.pdf]

Post, J.R., M. Sullivan, S. Cox, N.P. Lester, C.J. Walters, E.A. Parkinson, A.J. Paul, L. Jackson and B.J. Shuter, 2002: Canada's recreational fisheries: The invisible collapse? *Fisheries*, **27**, 6-17.

Postel, S. and B. Richter, 2003: *Rivers for Life: Managing Water for People and Nature*. Island Press, Washington, District of Columbia, 220 pp.

Pounds, A.J., 2001: Climate and amphibian declines. *Nature*, **410**, 639-640.

Pulwarty, R., K. Jacobs and R. Dole, 2005: The hardest working river: drought and critical water problems in the Colorado River Basin. *Drought and Water Crisis - Science, Technology and Management Issues*, D.A. Wilhite, Ed., CRC Press, Boca Raton, Florida, 249-286.

Quinn, F.H., 2002: The potential impacts of climate change on Great Lakes transportation. *The Potential Impacts of Climate Change on Transportation: Workshop Summary and Proceedings*, Washington, District of Columbia, 9 pp. [Accessed 12.02.07: http://climate.volpe.dot.gov/workshop1002/quinn.pdf]

Quinn, F.H. and B.M. Lofgren, 2000: The influence of potential greenhouse warming on Great Lakes hydrology, water levels, and water management. *Proc. 15th Conference on Hydrology.* Long Beach, California, American Meteorological Society Annual Meeting, 271-274.

Rahel, F.J., 2002: Using current biogeographic limits to predict fish distributions following climate change. *Fisheries in a Changing Climate*, N.A. McGinn, Ed., American Fisheries Society, 99-110.

Rayner, S., D. Lach and H. Ingram, 2005: Weather forecasts are for wimps: why water resource managers do not use climate forecasts. *Clim. Change*, **69**, 197-227.

Reale, D., A. McAdam, S. Boutin and D. Berteaux, 2003: Genetic and plastic responses of a northern mammal to climate change. *Proc. R. Soc. Lond. B*, 591-596.

Reed, K.M. and B. Czech, 2005: Causes of fish endangerment in the United States, or the structure of the American economy. *Fisheries (Bethesda)*, **30**, 36-38.

Regonda, S.K., B. Rajagopalan, M. Clark and J. Pitlick, 2005: Seasonal cycle shifts in hydroclimatology over the western United States. *Journal of Climate*, **18**, 372-384.

Rehfeldt, G.E., W.R. Wycoff and C. Ying, 2001: Physiologic plasticity, evolution and impacts of a changing climate on Pinus contorta. *Clim. Change*, **50**, 355-376.

Reid, W.V., H.A. Mooney, A. Cropper, D. Capistrano, S.R. Carpenter, K. Chopra, P. Dasgupta, T. Dietz, A.K. Duraiappah, R.K. Rashid Hassan, R. Leemans, R.M. May, T.A.J. McMichael, P. Pingali, C. Samper, R. Scholes, R.T. Watson, A.H. Zakri, Z. Shidong, N.J. Ash, E. Bennett, P. Kumar, M.J. Lee, C. Raudsepp-Hearne, H. Simons, J. Thonell and M.B. Zurek, 2005: *Ecosystems and human well-being*. Island Press, Washington, District of Columbia, 137 pp.

Reilly, J.M., Ed., 2002: *Agriculture: The Potential Consequences of Climate Variability and Change*. Cambridge University Press, Cambridge, 136 pp.

Reisen, W.K., Y. Fang and V. Martinez, 2006: Effects of temperature on the transmission of West Nile virus by *Culex tarsalis* (Diptera: Culicidae). *J. Med. Entomol.*, **43**, 309-317.

Report of the Water Strategy Expert Panel, 2005: *Watertight: The Case for Change in Ontario's Water and Wastewater sector.* Publications Ontario, Toronto, Canada.

Reynolds, R.W., N.A. Rayner, T.M. Smith, D.C. Stokes and W.Q. Wang, 2002: An improved in situ and satellite SST analysis for climate. *Journal of Climate*, **15**, 1609-1625.

Richardson, R.B. and J.B. Loomis, 2004: Adaptive recreation planning and climate change: a contingent visitation approach. *Ecol. Econ.*, **50**, 83-99.

Rivera, A., D.M. Allen and H. Maathuis, 2004: Climate variability and change - groundwater resources. *Threats to Water Availability in Canada*, Environment Canada, Eds., National Water Research Institute, Burlington, Ontario, 77-84. [Accessed 12.02.07: http://www.nwri.ca/threats2full/ThreatsEN_03web.pdf]

RM, 2003: Reducing electrical risk. *Risk Management*, **50(8)**, 10.

RMS, 2005a: *Estimating Losses from the 2004 Southeast Asia Earthquake and Tsunami,* Risk Management Solutions, Newark, California, 9 pp. [Accessed 12.02.07: http://www.rms.com/Publications/SumatraInsuredLoss_RMSwhite paper.pdf]

RMS, 2005b: *Hurricane Katrina: Profile of a Super Cat. Lessons and Implications for Catastrophe Risk Management,* Risk Management Solutions, Newark, California, 31 pp. [Accessed 12.02.07: http://www.rms.com/Publications/KatrinaReport_LessonsandImplications.pdf]

Rood, S.B., G.M. Samuelson, J.K. Weber and K.A. Wywrot, 2005: Twentieth-century decline in streamflows from the hydrographic apex of North America. *J. Hydrol.*, **306**, 215-233.

Root, T., J. Price, K. Hall, S. Schneiders, C. Rosenzweig and J. Pounds, 2003: Fingerprints of global warming on wild animals and plants. *Nature*, **421**, 57-60.

Root, T.L., D.P. MacMynowski, M.D. Mastrandrea and S.H. Schneider, 2005: Human-modified temperatures induce species changes: Joint attribution. *Proc. Natl. Acad. Sci.*, **102**, 7465-7469.

Ropelewski, C.F. and M.S. Halpert, 1986: North American precipitation and temperature patterns associated with the El Niño-Southern Oscillation (ENSO). *Month Wea. Rev.*, **114**, 2352-2362.

Rose, C.A., 2005: Economic growth as a threat to fish conservation in Canada. *Fisheries*, **30**, 36-38.

Rosenberg, N.J. and J.A. Edmonds, 2005: Climate change impacts for the conterminous USA: An integrated assessment: From Mink to the 'Lower 48': An introductory editorial *Clim. Change*, **69**, 1-6.

Rosenberg, N.J., D.J. Epstein, D. Wang, L. Vail, R. Srinivasan and J.G. Arnold, 1999: Possible impacts of global warming on the hydrology of the Ogallala aquifer region. *Clim. Change*, **42**, 677-692.

Rosenberg, N.J., R.A. Brown, R.C. Izaurralde and T.M. Thomson, 2003: Integrated assessment of Hadley Centre (HadCM2) climate change projections on agricultural productivity and irrigation water supply in the conterminous United States: I. Climate change scenarios and impacts on irrigation water supply simulated with the HUMUS model. *Agric. For. Meteorol.*, **117**, 73-96.

Rosenzweig, C. and W.D. Solecki, Eds., 2001: *Climate Change and a Global City: The Metropolitan East Coast Regional Assessment.* Columbia Earth Institute, New York, New York, 210 pp. [Accessed 12.02.07: http://metroeast_climate.ciesin.columbia.edu/sectors.html]

Rosenzweig, C., F.N. Tubiello, R. Goldberg, E. Mills and J. Bloomfield, 2002: Increased crop damage in the US from excess precipitation under climate change. *Global Environ. Change*, **12**, 197-202.

Rosenzweig, C., W.D. Solecki, L. Parshall, M. Chopping, G. Pope and R. Goldberg, 2005: The heat island effect and global climate change in urban New Jersey. *Glob. Environ. Change*, **6**, 51-62.

Rosetti, M.A., 2002: Potential impacts of climate change on railroads. *The Potential Impacts of Climate Change on Transportation: Workshop Summary and Proceedings*, Center for Climate Change and Environmental Forecasting, Federal Research Partnership Workshop, United States Department of Transportation, Washington, District of Columbia, 13 pp. [Accessed 12.02.07: http://climate.volpe.dot.gov/workshop1002/]

Running, S.W., 2006: Is global warming causing more larger wildfires? *Science*, **313**, 927-928.

Ruosteenoja, K., T.R. Carter, K. Jylha and H. Tuomenvirta, 2003: Future climate in world regions: an intercomparison of model-based projections for the new IPCC emissions scenarios. Finnish Environment Institute, Helsinki, 83 pp. [Accessed 12.02.07: http://www.environment.fi/download.asp?contentid=25835 &lan=en]

Ruth, M. and A.D. Amato, 2002: Regional energy demand responses to climate change: Methodology and applications to Massachusetts. *North American Meeting, Regional Science Association International*, San Juan, Puerto Rico, 24 pp.

Rybczyk, J.M. and D.R. Cahoon, 2002: Estimating the potential for submergence for two wetlands in the Mississippi River Delta. *Estuaries*, **25**, 985-998.

Rygel, L., D. O'Sullivan and B. Yarnal, 2006: A method for constructing a social vulnerability index. *Mitigation Adapt. Strategies for Global Change*, **11**, 741-764.

Sailor, D.J., 2001: Relating residential and commercial sector electricity loads to climate: Evaluating state level sensitivities and vulnerabilities. *Energy*, **26**, 645-657.

Sailor, D.J. and J.R. Muñoz, 1997: Sensitivity of electricity and natural gas consumption to climate in the U.S. - methodology and results for eight states. *Energy*, **22**, 987-998.

Sailor, D.J. and A.A. Pavlova, 2003: Air conditioning market saturation and long-term response of residential cooling energy demand to climate change. *Energy*, **28**, 941-951.

Sala, O.A., F.S. Chapin III, J.J. Armesto, E. Berlow, J. Bloomfield, R. Dirzo, E. Huber-Sanwald, L.F. Huenneke, R.B. Jackson, A. Kinzig, R. Leemans, D.M. Lodge, H.A. Mooney, M. Oesterheld, N.L. Poff, M.T. Sykes, B.H. Walker, M. Walker and D.H.Wall, 2000: Global biodiversity scenarios for the year 2100. *Science*, **287**, 1770-1774.

Sands, R.D. and J.A. Edmonds, 2005: Climate change impacts for the conterminous USA: An integrated assessment. Part 7: Economic analysis of field crops and land use with climate change. *Clim. Change*, **69**, 127-150.

Scavia, D., J.C. Field, D.F. Boesch, R.W. Buddemeier, V. Burkett, D.R. Cayan, M. Fogarty, M.A. Harwell, R.W. Howarth, C. Mason, D.J. Reed, T.C. Royer, A.H. Sallinger and J.G. Titus, 2002: Climate change impacts on U.S. coastal and marine ecosystems. *Estuaries*, **25**, 149-164.

Scheraga, J., 2001: Coping with climate change. *Upper Great Lakes Regional Climate Change Impacts Workshop - For the US National Assessment of Climate Change*, Ann Arbor, Michigan, 131-140.

Schertzer, W.M., W.R. Rouse, D.C.L. Lam, D. Bonin and L. Mortsch, 2004: Climate Variability and Change—Lakes and Reservoirs. *Threats to Water Resources in Canada*. Environment Canada, Ed., National Water Resources Institute, Burlington, Ontario. [Accessed 12.02.07: http://www.nwri.ca/threats2full /ch12-1-e.html]

Schindler, D., 2001: The cumulative effects of climate warming and other human stresses on Canadian freshwaters in the new millennium. *Can. J. Fish Aquat. Sci.*, **58**, 18-29.

Schindler, D.W. and W.F. Donahue, 2006: An impending water crisis in Canada's western prairie provinces. *Proc. Nat. Acad. Sci.*, **107**, doi/10.1073/pnas.0601568103.

Schipper, L., S. Huq and M. Kahn, 2003: An exploration of 'mainstreaming' adaptation to climate change. *Climate Change Research Workshop*, Stockholm Environment Institute IIED and TERI, New Delhi, 4 pp.

Schneider, S.H., 2004: Abrupt non-linear climate change, irreversibility and surprise. *Glob. Environ. Change*, **14**, 245-258.

Schoennagel, T., T.T. Veblen and W.H. Romme, 2004: The interaction of fire, fuels, and climate across Rocky Mountain Forests. *BioScience*, **54**, 661-676.

Schuster, C.J., A. Ellis, W.J. Robertson, J.J. Aramini, D.F. Charron and B. Marshall, 2005: Drinking water related infectious disease outbreaks in Canada, 1974-2001. *Can. J. Public Health*, **94**, 254-258.

Schwartz, J., J.M. Samet and J.A. Patz, 2004a: Hospital admissions for heart disease: the effects of temperature and humidity. *Epidemiology*, **15**, 755-761.

Schwartz, M. and B. Reiter, 2000: Changes in North American spring. *Int. J. Climatol.*, **20**, 929-993.

Schwartz, R.C., P.J. Deadman, D.J. Scott and L.D. Mortsch, 2004b: Modeling the impacts of water level changes on a Great Lakes community. *J. Amer. Water Resour. Assoc.*, **40**, 647-662.

Scott, D. 2005: Ski industry adaptation to climate change: hard, soft and policy strategies. *Tourism and Global Environmental Change*, S. Gossling and M. Hall, Eds., Routledge, Oxford, 265-285.

Scott, D., 2006: Climate Change Vulnerability of the Northeast U.S. Winter Recreation-Tourism Sector. *Technical Report Northeast Climate Impacts Assessment*, Union of Concerned Scientists, Cambridge, Massachusetts.

Scott, D. and B. Jones, 2005: Climate Change and Banff National Park: Implications for Tourism and Recreation – Executive Summary. Report prepared for the Town of Banff, Waterloo, Ontario, 29 pp.

Scott, D. and B. Jones, 2006: *Climate Change and Nature-Based Tourism: Implications for Park Visitation in Canada*, Government of Canada's Climate Change Action Fund - Impacts and Adaptation Program (project A714), 29 pp.

Scott, D., G. McBoyle and B. Mills, 2003: Climate change and the skiing industry in southern Ontario (Canada): exploring the importance of snowmaking as a technical adaptation. *Climate Res.*, **23**, 171-181.

Scott, D., G. McBoyle, B. Mills and A. Minogue, 2006: Climate change and the sustainability of ski-based tourism in eastern North America: A reassessment. *J. Sustainable Tourism*, **14**, 376-398.

Scott, D., B. Jones and J. Konopek, 2007a: Implications of climate and environmental change for nature-based tourism in the Canadian Rocky Mountains: A case study of Waterton Lakes National Park. *Tourism Management*, **28**, 570-579.

Scott, D., G. McBoyle and A. Minogue, 2007b: The implications of climate change for the Québec ski industry, *Global Environmental Change*, **17**, 181-190.

Scott, M.J., L.W. Vail, C.O. Stöckle and A. Kemanian, 2004: Climate change and adaptation in irrigated agriculture - a case study of the Yakima River, *Allocating Water: Economics and the Environment*, Portland, Oregon, Universities Council on Water Resources and The National Institutes for Water Resources, 7 pp.

Scott, M.J., J.A. Dirks and K.A. Cort, 2005: The Adaptive Value of Energy Efficiency Programs in a Warmer World: Building Energy Efficiency Offsets Effects of Climate Change. *Proc. 2005 International Energy Program Evaluation Conference*, Brooklyn, New York.

Segal, M., Z. Pan, R.W. Arritt and E.S. Takle, 2001: On the potential change in wind power over the US due to increases of atmospheric greenhouse gases. *Renew. Energ.*, **24**, 235-243.

Select Bipartisan Committee, 2006: A Failure of Initiative: Final Report of the Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina. Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina, U.S. House of Representatives (Select Committee), 109th Congress, U.S. Government Printing Office, Washington, District of Columbia, 379 pp. +Appencies. [Accessed 12.02.07: http://katrina.house.gov/full_katrina_report.htm]

Senate of Canada, 2003: Climate Change: We are at Risk. Final Report, Standing Senate Committee on Agriculture and Forestry, Ottawa, Canada, 123 pp.

Shabbar, A., B. Bonsal and M. Khandekar, 1997: Canadian precipitation patterns associated with the Southern Oscillation. *J. Climate*, **10**, 3016-3027.

Shaw, J., R.B. Taylor, D.L. Forbes, M.-H. Ruz and S. Solomon, 1998: *Sensitivity of the Coasts of Canada to Sea-Level Rise*, Bulletin 505, Natural Resources Canada, Geological Survey of Canada, Ottawa,79 pp.

Shein, K.A., 2006: State of the climate in 2005, including executive summary. *Bull. Amer. Meteorol. Soc.*, **87**, 801-805, s801-s102.

Sheridan, S.C. and L.S. Kalkstein, 2004: Progress in heat watch-warning system technology. *Bull. Amer. Meteorol. Soc.*, **85**, 1931-1941.

Shushama, L., R. Laprise, D. Caya, A. Frigon and M. Slivitzky, 2006: Canadian RCM projected climate-change signal and its sensitivity to model errors. *Int. J. Climatol.*, **26**, doi: 10.1002/joc.1362.

Shuter, B.J., C.K. Minns and N. Lester, 2002: Climate change, freshwater fish, and fisheries: Case studies from Ontario and their use in assessing potential impacts. *Fisheries in a Changing Climate*, N.A. McGinn, Ed., American Fisheries Society, 77-88.

Simmons, K., J. Kruse and D. Smith, 2002: Valuing mitigation: Real estate market response to hurricane loss reduction measures. *Southern Econ. J.*, **68** , 660-671.

Simonovic, S.P. and L. Li, 2004: Sensitivity of the Red River Basin flood protection system to climate variability and change. *Water Resour. Manag.*, **18**, 89-110.

Slovic, P., Ed., 2000: *The Perception of Risk*. Earthscan Publications, London, 518 pp.

Small, C. and R.J. Nichols, 2003: A global analysis of human settlement. *J. Coastal Res.*, **19**, 584-599.

Smit, B. and M.W. Skinner, 2002: Adaptation options in agriculture to climate change: A typology. *Mitigation Adapt. Strategies Global Change*, **7**, 85-114.

Smit, B. and E. Wall, 2003: *Adaptation to Climate Change Challenges and Opportunities: Implications and Recommendations for the Canadian Agri-Food Sector*, Senate Standing Committee on Forestry and Agriculture, Ottawa, Canada. [Accessed 12.02.07: http://www.parl.gc.ca/37/2/parlbus/commbus/senate/Com-e/agri-e/power-e/smith-e.htm]

Smit, B., I. Burton, R.J.T. Klein and J. Wandel, 2000: An anatomy of adaptation to climate change and variability. *Climatic Change*, **45**, 223-251.

Smith, O.P. and G. Levasseur, 2002: Impacts of climate change on transportation infrastructure in Alaska. *The Potential Impacts of Climate Change on Transportation: Workshop Summary and Proceedings*, Washington District of Columbia, 11 pp. [Accessed 12.02.07: http://climate.volpe.dot.gov/ workshop1002/smith.pdf]

Smith, S.D., T.E. Huxman, S.F. Zitzer, T.N. Charlet, D.C. Housman, J.S. Coleman, L.K. Fenstermaker, J.R. Seemann and R.S. Nowak, 2000: Elevated $CO_2$ increases productivity and invasive species success in an arid ecosystem. *Nature*, **408**, 79 - 82.

Smith, S.J., A.M. Thomson, N.J. Rosenberg, R.C. Izaurralde, R.A. Brown and T.M.L. Wigley, 2005: Climate change impacts for the conterminous USA: An integrated assessment: Part 1. Scenarios and context. *Clim. Change*, **69**, 7-25.

Snyder, M.A., J.L. Bell, L.C. Sloan, P.B. Duffy and B. Govindasamy, 2002: Climate responses to a doubling of atmospheric carbon dioxide for a climatically vulnerable region. *Geophys. Res. Lett.*, **29**, doi:10.1029/2001GL014431.

Sohngen, B. and R. Sedjo, 2005: Impacts of climate change on forest product markets: Implications for North American producers. *Forestry Chron.*, **81**, 669-674.

Soil and Water Conservation Society, 2003: *Conservation Implications of Climate Change: Soil Erosion and Runoff from Cropland*, a report from the Soil and Water Conservation Society, Ankeny, Iowa, 26 pp. [Accessed 12.02.07: http://www.swcs.org/documents/Climate_changefinal_112904154622.pdf]

Solecki, W.D. and C. Rosenzweig, 2007: Climate change and the city: Observations from Metropolitan New York. *Urbanization and Environmental Change: Cities as Environmental Hero*, X. Bai, T. Graedel and A. Morishima. Eds., Yale University Press, New Haven, Conneticut. (in press).

Southwick Associates, 2006: *The Economic Contribution of Active Outdoor Recreation*. Outdoor Industry Foundation, Boulder, Colorado, 85 pp.

Southworth, J., R.A. Pfeifer, M. Habeck, J.C. Randolph, O.C. Doering, J.J. Johnston and D.G. Rao, 2002: Changes in soybean yields in the Midwestern United States as a result of future changes in climate, climate variability, and $CO_2$ fertilization. *Clim. Change*, **53**, 447-475.

Spittlehouse, D.L. and R.B. Stewart, 2003: Adaptation to climate change in forest management. *BC J. Ecosyst. Manag.*, **4**, 1-11.

St. Lawrence River-Lake Ontario Plan of Study Team, 1999: *Plan of study for criteria review in the orders of approval for regulation of Lake Ontario - St. Lawrence River levels and flows,* International Joint Commission. [Accessed 12.02.07: http://www.ijc.org/php/publications/html/pos/pose.html]

Statistics Canada, 2001a: *Population projections for Canada, provinces and territories, 2000-2026,* Statistics Canada, Ottawa, Ontario, 202 pp.

Statistics Canada, 2001b: *Population urban and rural, by province and territory (Canada),* Statistics Canada, Ottawa, Ontario. [Accessed 12.02.07: http://www40.statcan.ca/l01/cst01/demo62a.htm]

Statistics Canada, 2006: *Agriculture Value Added Account: Agriculture Economic Statistics: June 2006.* Statistics Canada, Ottawa, Ontario. [Accessed 12.02.07: http://www.statcan.ca/english/freepub/21-017-XIE/2006001/t026_en.htm?]

Stefan, H.G. and X. Fang, 1999: Simulation of global climate-change impact on temperature and dissolved oxygen in small lakes of the contiguous U.S.. *Proc. of the Specialty Conference on Potential Consequences of Climate Variability and Change to Water Resources of the United States*, American Water Resources Association.

Stefan, H.G., X. Fang and J.G. Eaton, 2001: Simulated fish habitat changes in north American lakes in response to projected climate warming. *Trans. Amer. Fish. Soc.*, **130**, 459-477.

Stewart, I.T., D.R. Cayan and M.D. Dettinger, 2005: Changes toward earlier streamflow timing across western North America. *J. Climate*, **18**, 1136-1155.

Stiger, R.W., 2001: Alaska DOT deals with permafrost thaws. *Better Roads*. June, 30-31. [Accessed 12.02.07: http://obr.gcnpublishing.com/articles/brjun01c.htm]

Stiglitz, J.E., 2002: *Globalization and its Discontents*. Norton. 304 pp.

Stocks, B.J., J.A. Mason, J.B. Todd, E.M. Bosch, B.M. Wotton, B.D. Amiro, M.D. Flannigan, K.G. Hirsch, K.A. Logan, D.L. Martell and W.R. Skinner, 2002: Large forest fires in Canada, 1959-1997. *J. Geophys. Res.*, **107**, doi:10.1029/2001JD000484.

Stone, M.C., R.H. Hotschkiss, C.M. Hubbard, T.A. Fontaine, L.O. Mearns and J.G. Arnold, 2001: Impacts of climate change on Missouri River basin water yield. *J. Amer. Water Resour. Assoc.*, **37**, 1119-1129.

Stone, M.C., R. Hotchkiss and L.O. Mearns, 2003: Water yield responses to high and low spatial resolution climate change scenarios in the Missouri River Basin. *Geophys. Res. Lett.*, **30**, doi:10.1029/2002GL016122.

Stonefelt, M.D., T.A. Fontaine and R.H. Hotchkiss, 2000: Impacts of climate change on water yield in the Upper Wind River Basin. *J. Amer. Water Resour. Assoc.*, **36**, 321-336.

Stott, P.A., 2003: Attribution of regional-scale temperature changes to anthropogenic and natural causes. *Geophys. Res. Lett.*, **30**, doi:10.1029/2003GL017324.

Suarez, P., W. Anderson, V. Mahal and T.R. Lakshmanan, 2005: Impacts of flooding and climate change on urban transportation: A systemwide performance assessment of the Boston Metro Area *Transport. Res. D-Tr. E.*, **10**, 231-244.

Swiss Re, 2005a: *Hurricane Season 2004: Unusual, but not Unexpected,* Swiss Reinsurance Company, Zurich, 12 pp. [Accessed 12.02.07: http://www.swissre.com/INTERNET/pwswpspr.nsf/fmBookMarkFrameSet?ReadForm&BM=../vwAllbyIDKeyLu/ulur-66jcv9?OpenDocument]

Swiss Re, 2005b: *Large Loss Fact Files: Hurricane Ivan,* Swiss Re Publishing, Zurich. [Accessed 12.02.07:http://www.swissre.com/INTERNET/pwswpspr.nsf/fmBookMarkFrameSet?ReadForm&BM=../vwAllbyIDKeyLu/mbui-4v7f68?OpenDocument]

Swiss Re, 2005c: *Large Loss Fact Files: Hurricane Katrina,* Swiss Re Publishing, Zurich. [Accessed 12.02.07:http://www.swissre.com/INTERNET/pwswpspr.nsf/fmBookMarkFrameSet?ReadForm&BM=../vwAllbyIDKeyLu/mbui-4v7f68?OpenDocument]

Swiss Re, 2005d: *Large Loss Fact Files: Hurricane Rita,* Swiss Re Publishing, Zurich. Accessed 12.02.07:http://www.swissre.com/INTERNET/pwswpspr.nsf/fmBookMarkFrameSet?ReadForm&BM=../vwAllbyIDKeyLu/mbui-4v7f68?OpenDocument]

Swiss Re, 2005e: *Large Loss Fact Files: Hurricane Wilma,* Swiss Re Publishing, Zurich. Accessed 12.02.07:http://www.swissre.com/INTERNET/pwswpspr.nsf/fmBookMarkFrameSet?ReadForm&BM=../vwAllbyIDKeyLu/mbui-4v7f68?OpenDocument]

Thomas, C.D., A. Cameron, R.E. Green, M. Bakkenes, L.J. Beaumont, Y.C. Collingham, B.F.N. Erasmus, M.F. d. Siqueira, A. Grainger, L. Hannah, L. Hughes, B. Huntley, A.S. v. Jaarsveld, G.F. Midgley, L. Miles, M.A. Ortega-Huerta, A.T. Peterson, O.L. Phillips and S.E. Williams, 2004: Extinction risk from climate change. *Nature*, **427**, 145-148.

Thomas, M.K., D.F. Charron, D. Waltner-Toews, C. Schuster, A.R. Maarouf and J.D. Holt, 2006: A role of high impact weather events in waterborne disease outbreaks in Canada, 1975-2001. *Int. J. Environ. Health Res.*, **16**, 167-180.

Thomson, A.M., R.A. Brown, N.J. Rosenberg and R.C. Izaurralde, 2005a: Climate change impacts for the conterminous USA: An integrated assessment. Part 2: Models and Validation. *Clim. Change*, **69**, 27-41.

Thomson, A.M., R.A. Brown, N.J. Rosenberg and R.C. Izaurralde, 2005b: Climate change impacts for the conterminous USA: An integrated assessment. Part 5: Irrigated agriculture and national grain crop production. *Clim. Change*, **69**, 89-105.

Thomson, A.M., R.A. Brown, N.J. Rosenberg, R.C. Izaurralde and V. Benson, 2005c: Climate change impacts for the conterminous USA: An integrated assessment. Part 3: Dryland production of grain and forage crops. *Clim. Change*, **69**, 43-65.

Thomson, A.M., R.A. Brown, N.J. Rosenberg, R.C. Izaurralde and R. Srinivasan, 2005d: Climate change impacts for the conterminous USA: An integrated assessment. Part 4: Water resources. *Clim. Change*, **69**, 67-88.

Tierney, K., 2006: Social inequality, hazards, and disasters. *On Risk and Disaster*, H. Kunreuther, R. Danielsand, D. Kettl, Eds., University of Pennsylvania Press, Philadelphia, Pennsylvania.

Titus, J., 2002: Does sea level rise matter to transportation along the Atlantic coast? *The Potential Impacts of Climate Change on Transportation: Workshop Summary and Proceedings*, Washington District of Columbia, 16 pp. [Accessed 12.02.07: http://climate.volpe.dot.gov/workshop1002/titus.pdf]

Titus, J.G., 2005: Sea-level rise effect. *Encyclopaedia of Coastal Science*, M.L. Schwartz, Ed., Springer, Dordrecht, 838-846.

Titus, J.G. and C. Richman, 2001: Maps of lands vulnerable to sea level rise: modeled elevations along the US Atlantic and Gulf Coasts. *Climate Res.*, **18**, 205-228.

Tol, R.S.J., 2002: Estimates of the damage costs of climate change. Part 1: Benchmark estimates. *Environ. Resour. Econ.*, **21**, 47-73.

Trenberth, K.E., P.D. Jones, P. Ambenje, R. Bojariu, D. Easterling, A. Klein Tank, D. Parker, F. Rahimzadeh, J. A. Renwick, M. Rusticucci, B. Sodin and P. Zhai, 2007: Observations: surface and atmospheric change. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,* S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Eds., Cambridge University Press, Cambridge and New York, 235-336.

Troyer, A.F., 2004: Background of U.S. Hybrid Corn II: Breeding, Climate, and food. *Crop Science*, **44**, 370-380.

Tsvetsinskaya, E.A., L.O. Mearns, T. Mavromatis, W. Gao, L. McDaniel and M.W. Downton, 2003: The effect of spatial scale of climatic change scenarios on simulated maize, winter wheat, and rice production in the southeastern United States. *Clim. Change*, **60**, 37-72.

Turner, B.L., II, R.E. Kasperson, P.A. Matson, J.J. McCarthy, R.W. Corell, L. Christensen, N. Eckley, J.X. Kasperson, A. Luers, M.L. Martello, C. Polsky, A. Pulsipher and A. Schiller, 2003: A framework for vulnerability analysis in sustainability science. *Proc. Nat. Acad. Sci.*, **100**, 8074-8079.

UMA Engineering, 2005: *Flood Reduction Master Plan,* City of Peterborough, Peterborough, Canada.

UNDP, 2001: Workshop for Developing and Adaptation Policy Framework for Climate Change. June 2001, United Nations Development Program, Montreal, Canada.

UNECE, 2005a: Trends in Europe and North America - 2OO5: Canada. United Nations Economic Commission for Europe, 2 pp. [Accessed 12.02.07: http://www.unece.org/stats/trends2005/profiles/Canada.pdf]

UNECE, 2005b: Trends in Europe and North America - 2OO5: United States. United Nations Economic Commission for Europe, 2 pp. [Accessed 12.02.07: http://www.unece.org/stats/trends2005/profiles/UnitedStates.pdf]

UNPD, 2005: *World Population Prospects: The 2004 Revision*. United Nations Population Division, New York, New York. [Accessed 12.02.07: http://esa.un.org/unpp/]

Vasquez-Leon, M., C.T. West, B. Wolf, J. Moody and T.J. Finan, 2002: *Vulnerability to Climate Variability in the Farming Sector - A Case Study of Groundwater-Dependant Agriculture in Southeastern Arizona*. The Climate Assessment Project for the South West, Report Series CL 1-02, Institute for the Study of Planet Earth, University of Arizona, Tucson, Arizona, 100 pp. [Accessed 12.02.07: http://www.ispe.arizona.edu/climas/pubs/CL1-02.html]

Vincent, L. and E. Mekis, 2006: Changes in daily and extreme temperature and precipitation indices for Canada over the twentieth century *Atmosphere-Ocean*, **44**, 177-193.

Volney, W.J.A. and R.A. Fleming, 2000: Climate change and impacts of boreal forest insects. *Agric. Ecosyst. Environ.*, **82**, 283-294.

Walker, I.J. and J.V. Barrie, 2006: Geomorphology and sea-level rise on one of Canada's most 'sensitive' coasts: northeast Graham Island, British Columbia. *J. Coastal Res.*, **SI 39**, 220-226.

Ker, R.R., 2001: Climate change assessment at a watershed scale. *Water and Environment Association of Ontario Conference*, Toronto, Canada, 12 pp.

Wall, E. and B. Smit, 2005: Climate change adaptation in light of sustainable agriculture. *J. Sustainable Agric.*, **27**, 113-123.

Wall, E., B. Smitand, J. Wandell, 2005: From silos to synthesis: Interdisciplinary issues for climate change impacts and adaptation Research. *Canadian Association of Geographers special session series: Communities and climate change impacts, adaptation and vulnerability, agriculture*, C-CIARN, Moncton, New Brunswick, 24 pp. [Accessed 12.02.07: http://www.c-ciarn.uoguelph.ca/documents/cciarn_ silostosyn_0105.pdf]

Walsh, M.E., D.G. de la Torre Ugarte, H. Shapouriand, S.P. Slinsky, 2003: Bioenergy crop production in the United States. *Environ. Res. Econ.*, **24**, 313-333.

Walter, M.T., D.S. Wilks, J.Y. Parlange and B.L. Schneider, 2004: Increasing evapotranspiration from the conterminous United States. *J. Hydrometeorol.*, **5**, 405-408.

Walther, G.-R., E. Post, A. Menzel, P. Convey, C. Parmesan, F. Bairlen, T. Beebee, J.M. Fromont, O. Hoegh-Guldberg and F. Bairlein, 2002: Ecological responses to recent climate change. *Nature*, **416**, 389-395.

Waters, D., W.E. Watt, J. Marsalek and B.C. Anderson, 2003: Adaptation of a storm drainage system to accommodate increased rainfall resulting from climate change *J. Environ. Plan. Manag.*, **46**, 755-770.

Wayne, P., S. Foster, J. Connolly, F. Bazzaz and P. Epstein, 2002: Production of allergenic pollen by ragweed (*Ambrosia artemisiifolia* L.) is increased in $CO_2$-enriched atmospheres. *Ann. Alerg. Asthma Im.*, **88**, 279-282.

Weisskopf, M.G., H.A. Anderson, S. Foldy, L.P. Hanrahan, K. Blair, T.J. Torok and P.D. Rumm, 2002: Heat wave morbidity and mortality, Milwaukee, Wis, 1999 vs 1995: An improved response? *Amer. J. Public Health*, **92**, 830-833.

Welch, C., 2006: Sweeping change reshapes Arctic. *The Seattle Times*. Jan. 1 2006. [Accessed 12.02.07: http://seattletimes.nwsource.com/html/localnews/2002714404_arctic01main.html]

West, J.J., M.J. Small and H. Dowlatabadi, 2001: Storms, investor decisions, and the economic impacts of sea level rise. *Clim. Change*, **48**, 317-342.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan and T.W. Swetnam, 2006: Warming and earlier spring increase western U.S. forest wildfire activity. *Science*, **313**, 940-943.

Wetherald, R.T. and S. Manabe, 2002: Simulation of hydrologic changes associated with global warming. *J. Geophys. Res.*, **107**, doi: 10.1029/2001JD00195,02002.

Wheaton, E., V. Wittrock, S. Kulshretha, G. Koshida, C. Grant, A. Chipanshi and B. Bonsal, 2005: *Lessons Learned from the Canadian Drought Years of 2001 and 2002: Synthesis Report*. Saskatchewan Research Council Publication No. 11602-46E03, Saskatoon, Saskatchewan, 38 pp. [Accessed 12.02.07: http://www.agr.gc.ca/pfra/drought/info/11602-46E03.pdf]

White, M.A., N.S. Diffenbaugh, G.V. Jones, J.S. Pal and F. Giorgi, 2006: Extreme heat reduces and shifts United States premium wine production in the 21st century. *PNAS*, **103**, 11217-11222. doi: 10.1073/pnas.0603230103.

Whitfield, P.H. and A.J. Cannon, 2000: Recent variations in climate and hydrology in Canada. *Can. Water Resour. J.*, **25**, 19-65.

WHO, 2003: *Climate Change and Human Health – Risk and Responses*. World Health Organization, New York, New York, 250 pp.

Wilbur, H.M., 1997: Experimental ecology of food webs: complex systems in temporary ponds. *Ecology*, **78**, 2279-2302.

Wilgoren, J. and K.R. Roane, 1999: Cold Showers, Rotting Food, the Lights, Then Dancing. *New York Times*, A1. July 8, 1999.

Williams, D.W. and A.M. Liebhold, 2002: Climate change and the outbreak ranges of two North American bark beetles. *Agric. For. Meteorol.*, **4**, 87-99.

Winkler, J.A., J.A. Andresen, G. Guentchev and R.D. Kriegel, 2002: Possible impacts of projected temperature change on commercial fruit production in the Great Lakes Region. *J. Great Lakes Res.*, **28**, 608-625.

Wolfe, D.W., M.D. Schwartz, A.N. Lakso, Y. Otsuki, R.M. Pool and N.J. Shaulis, 2005: Climate change and shifts in spring phenology of three horticultural woody perennials in northeastern USA. *Int. J. Biometeorol.*, **49**, 303-309.

Woods, A., K.D. Coates and A. Hamann, 2005: Is an unprecedented dothistroma needle blight epidemic related to climate change? *BioScience*, **55**, 761-769.

Woodward, F.I. and M.R. Lomas, 2004: Vegetation dynamics - Simulating responses to climatic change. *Biol. Rev.*, **79**, 643-370.

World Tourism Organization, 2002: *Tourism Highlights 2001*, WTO Publications Unit - World Tourism Organization, Madrid.

Wrona, F.J., T.D. Prowse and J.D. Reist. 2005: Freshwater Ecosystems and Fisheries. *ACIA. Arctic Climate Impact Assessment*, Cambridge University Press, New York, 353-452. [Accessed 12.02.07: http://www.acia.uaf.edu/]

Wu, S.Y., B. Yarnal and A. Fisher, 2002: Vulnerability of coastal communities to sea-level rise: a case study of Cape May County, New Jersey, USA. *Climate Res.*, **22**, 255-270.

Yarnal, B., A.L. Heasley, R.E. O'Connor, K. Dow and C.L. Jocoy, 2006: The potential use of climate forecasts by community water system managers. *Land Use Water Resour. Res.*, **6**, 3.1-3.8.

Yohe, G. and R.S.J. Tol, 2002: Indicators for ecological and economic coping capacity: Moving forward a working definition of adaptive capacity. *Global Environ. Change*, **12**, 25-40.

Zavaleta, E.S. and K.B. Hulvey, 2004: Realistic species losses disproportionately reduce grassland resistance to biological invaders. *Science*, **306**, 1175-1177.

Zervas, C.E., 2001: *Sea Level Variations of the United States: 1854-1999*, National Ocean Service, Technical Report NOS CO-OPS 36, National Oceanic and Atmospheric Administration, Silver Spring, Maryland, 201 pp. [Accessed 12.02.07: http://tidesandcurrents.noaa.gov/publications/techrpt36doc.pdf]

Zhang, K.Q., B.C. Douglas and S.P. Leatherman, 2000: Twentieth-century storm activity along the U.S. east coast. *J. Climate*, **13**, 1748-1761.

Zhang, X., K. Harvey, W. Hogg and T. Yuzyk, 2001: Trends in Canadian streamflow. *Water Resour. Res.*, **37**, 987-998.

Zimmerman, R., 2002: Global climate change and transportation infrastructure: lessons from the New York area. *The Potential Impacts of Climate Change on Transportation: Workshop Summary and Proceedings*, Washington District of Columbia, 11 pp. [Accessed 12.02.07: http://climate.volpe.dot.gov/workshop1002/zimmermanrch.pdf]

Ziska, L.H., D.E. Gebhard, D.A. Frenz, S. Faulkner, B.D. Singer and J.G. Straka, 2003: Cities as harbingers of climate change: Common ragweed, urbanization, and public health. *J. Allergy Clin. Immunol.*, **111**, 290-295.

Zolbrod, A.N. and D.L. Peterson, 1999: Response of high-elevation forests in the Olympic Mountains to climatic change. *Can. J. For. Res.*, **29**, 1966-1978.

Zwiers, F. and X. Zhang, 2003: Toward regional-scale climate change detection. *J. Climate*, **16**, 793-797.

Attachment 30

STATE OF CALIFORNIA
THE RESOURCES AGENCY

FILE ID: R198888

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1988

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

DATE: 02/16/88
PAGE: 1

1988

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE TOTAL = | 1200 | | | | | | | |
| | | M&I ENT = | 1200 | | | | | |
| PLUMAS CO FCWCD TOTAL = | 960 | | | | | | | |
| | | M&I ENT = | 960 | | | | | |
| YUBA CITY TOTAL = | 1400 | | | | | | | |
| | | M&I ENT = | 1400 | | | | | |
| NAPA CO FCWCD TOTAL = | 5745 | | | | | | | |
| | | M&I ENT = | 5745 | | | | | |
| SOLANO CO FCWCD TOTAL = | 26820 | | | | | | | |
| TOT ENT = | 15660 | M&I ENT = | 700 | BEN ENT = | 10860 | VAL ENT = | 4100 | |
| TOT MISC = | 11160 | VAL PMT = | 11160 | | | | | |
| ZONE-7 ALAMEDA TOTAL = | 30000 | | | | | | | |
| TOT ENT = | 30000 | M&I ENT = | 21493 | M GW ENT = | 6212 | AGR ENT = | 2295 | |
| ALAMEDA CO WD TOTAL = | 40165 | | | | | | | |
| TOT ENT = | 34500 | M&I ENT = | 8775 | M GW ENT = | 22525 | A GW ENT = | 3200 | |
| TOT MISC = | 5665 | WET WTHR = | 5665 | | | | | |
| SANTA CLARA VWD TOTAL = | 88000 | | | | | | | |
| TOT ENT = | 88000 | M&I ENT = | 85370 | M GW ENT = | 2630 | | | |
| DEVIL'S DEN WD TOTAL = | 20000 | | | | | | | |
| | | AGR ENT = | 12700 | | | | | |
| | | AGR SUR = | 7300 | | | | | |
| DUDLEY RIDGE WD TOTAL = | 55639 | | | | | | | |
| | | AGR ENT = | 53500 | | | | | |
| | | AGR SUR = | 2139 | | | | | |
| EMPIRE WS ID TOTAL = | 6000 | | | | | | | |
| | | AGR ENT = | 3000 | | | | | |
| | | AGR SUR = | 3000 | | | | | |
| KERN COUNTY WA TOTAL = | 1225892 | | | | | | | |
| TOT ENT = | 1074600 | M&I ENT = | 46220 | M GW ENT = | 77680 | AGR ENT = | 950700 | |
| TOT SUR = | 151292 | AGR SUR = | 151292 | | | | | |
| COUNTY OF KINGS TOTAL = | 4000 | | | | | | | |
| | | M&I ENT = | 4000 | | | | | |
| OAK FLAT WD TOTAL = | 7300 | | | | | | | |
| | | AGR ENT = | 5400 | | | | | |
| | | AGR SUR = | 1900 | | | | | |

STATE OF CALIFORNIA
THE RESOURCES AGENCY

FILE ID: R198888

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1988

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

DATE: 02/16/88
PAGE: 2

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TULARE LK BWSD | TOTAL = 225000 | AGR ENT = 105600 | | | | | |
| | | AGR SUR = 106500 | | | | | |
| | | WET WTHR = 12900 | | | | | |
| AVEK WA | TOTAL = 46000 | | | | | | |
| | TOT ENT = 46000 | M&I ENT = 24000 | AGR ENT = 22000 | | | | |
| CASTAIC LAKE WA | TOTAL = 18400 | M&I ENT = 18400 | | | | | |
| COACHELLA VALLY | TOTAL = 20652 | M GW ENT = 20652 | | | | | |
| CRESTLINE-LA WA | TOTAL = 2000 | M&I ENT = 2000 | | | | | |
| DESERT WA | TOTAL = 34000 | M&I ENT = 34000 | | | | | |
| LITTLEROCK CR | TOTAL = 1953 | | | | | | |
| | TOT ENT = 1953 | M&I ENT = 100 | AGR ENT = 1853 | | | | |
| METROPOLITAN WD | TOTAL = 1026348 | | | | | | |
| | TOT ENT = 1026348 | M&I ENT = 750048 | M GW ENT = 86000 | BYPS ENT = 190300 | | | |
| PALMDALE WD | TOTAL = 6210 | M&I ENT = 6210 | | | | | |
| SAN BERNARDINO | TOTAL = 23000 | | | | | | |
| | TOT ENT = 23000 | M&I ENT = 9600 | M GW ENT = 13400 | | | | |
| SAN GABRIEL | TOTAL = 10500 | M GW ENT = 10500 | | | | | |
| SHELL CAL PROD. | TOTAL = 2295 | REPAYMNT = 2295 | | | | | |
| JG BOSWELL | TOTAL = 8000 | REPAYMNT = 8000 | | | | | |
| FISH & GAME | TOTAL = 660 | REC/F&WL = 660 | | | | | |
| PARKS & RECREAT | TOTAL = 90 | REC/F&WL = 90 | | | | | |
| REC/FISH&WILDLF | TOTAL = 7130 | REC/F&WL = 7130 | | | | | |

FILE DUMP

FILE IDENTIFICATION: R198888 02/16/88. SHEET 1

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT10 | FR | 50 | 50 | 120 | 70 | 70 | 90 | 170 | 200 | 170 | 90 | 60 | 60 | 1200 |
| *** TOTAL *** | | | 50 | 50 | 120 | 70 | 70 | 90 | 170 | 200 | 170 | 90 | 60 | 60 | 1200 |
| PLUMAS CO FCWCD | M&I ENT=WT10 | FR | 24 | 29 | 40 | 73 | 94 | 138 | 152 | 152 | 152 | 39 | 34 | 33 | 960 |
| *** TOTAL *** | | | 24 | 29 | 40 | 73 | 94 | 138 | 152 | 152 | 152 | 39 | 34 | 33 | 960 |
| YUBA CITY | M&I ENT=WT10 | FR | 0 | 0 | 0 | 0 | 0 | 0 | 500 | 500 | 300 | 100 | 0 | 0 | 1400 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 500 | 500 | 300 | 100 | 0 | 0 | 1400 |
| NAPA CO FCWCD | M&I ENT=WT10 | 3NB | 932 | 467 | 65 | 261 | 539 | 602 | 665 | 708 | 593 | 344 | 272 | 297 | 5745 |
| *** TOTAL *** | | | 932 | 467 | 65 | 261 | 539 | 602 | 665 | 708 | 593 | 344 | 272 | 297 | 5745 |
| SOLANO CO FCWCD | M&I ENT=WT10 | 1NB | 70 | 70 | 70 | 70 | 70 | 70 | 0 | 0 | 70 | 70 | 70 | 70 | 700 |
| SOLANO CO FCWCD | VAL PMT =WT71 | 1NB | 55 | 55 | 55 | 115 | 200 | 300 | 400 | 400 | 240 | 150 | 85 | 55 | 2110 |
| SOLANO CO FCWCD | BEN ENT =WT46 | 3NA | 790 | 622 | 803 | 931 | 1004 | 915 | 1066 | 1056 | 1004 | 972 | 909 | 788 | 10860 |
| SOLANO CO FCWCD | VAL ENT =WT47 | 3NA | 363 | 363 | 365 | 365 | 366 | 366 | 226 | 226 | 365 | 365 | 365 | 365 | 4100 |
| SOLANO CO FCWCD | VAL PMT =WT71 | 3NA | 300 | 300 | 300 | 750 | 1020 | 1070 | 1480 | 1480 | 1000 | 750 | 300 | 300 | 9050 |
| *** TOTAL *** | | | 1578 | 1410 | 1593 | 2231 | 2660 | 2721 | 3172 | 3162 | 2679 | 2307 | 1729 | 1578 | 26820 |
| ZONE-7 ALAMEDA | M&I ENT=WT10 | 1SB | 2 | 1 | 3 | 8 | 21 | 31 | 33 | 36 | 29 | 21 | 7 | 3 | 195 |
| ZONE-7 ALAMEDA | M&I ENT=WT10 | 2SB | 405 | 376 | 453 | 609 | 920 | 1083 | 1213 | 1141 | 880 | 625 | 405 | 409 | 8519 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 4SB | 257 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 3106 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 4SB | 1 | 1 | 82 | 223 | 387 | 404 | 414 | 380 | 18 | 113 | 1 | 1 | 2025 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 5SB | 257 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 259 | 3106 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 5SB | 0 | 0 | 0 | 10 | 30 | 30 | 30 | 10 | 0 | 10 | 0 | 0 | 120 |
| ZONE-7 ALAMEDA | M&I ENT=WT10 | 6SB | 609 | 564 | 679 | 914 | 1380 | 1624 | 1820 | 1712 | 1320 | 937 | 607 | 613 | 12779 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 6SB | 0 | 0 | 0 | 5 | 20 | 40 | 45 | 35 | 5 | 0 | 0 | 0 | 150 |
| *** TOTAL *** | | | 1531 | 1460 | 1735 | 2287 | 3276 | 3730 | 4073 | 3832 | 2770 | 2224 | 1538 | 1544 | 30000 |
| ALAMEDA CO WD | M GW ENT=WT08 | 7SB | 975 | 1125 | 1470 | 2055 | 2300 | 2645 | 2570 | 2570 | 2570 | 1955 | 1515 | 775 | 22525 |
| ALAMEDA CO WD | A GW ENT=WT22 | 7SB | 0 | 0 | 0 | 300 | 400 | 400 | 400 | 400 | 400 | 400 | 300 | 200 | 3200 |
| ALAMEDA CO WD | WET WTHR=WT07 | 7SB | 0 | 0 | 310 | 0 | 370 | 815 | 1020 | 1020 | 595 | 405 | 265 | 865 | 5665 |
| ALAMEDA CO WD | M&I ENT=WT10 | 8SB | 829 | 829 | 829 | 414 | 829 | 829 | 829 | 829 | 829 | 414 | 829 | 486 | 8775 |
| *** TOTAL *** | | | 1804 | 1954 | 2609 | 2769 | 3899 | 4689 | 4819 | 4819 | 4394 | 3174 | 2909 | 2326 | 40165 |
| SANTA CLARA VWD | M&I ENT=WT10 | 9SB | 4950 | 4200 | 5130 | 7950 | 8900 | 9200 | 9680 | 9680 | 9680 | 6500 | 4900 | 4600 | 85370 |
| SANTA CLARA VWD | M GW ENT=WT08 | 9SB | 200 | 200 | 200 | 0 | 780 | 480 | 0 | 0 | 0 | 370 | 200 | 200 | 2630 |
| *** TOTAL *** | | | 5150 | 4400 | 5330 | 7950 | 9680 | 9680 | 9680 | 9680 | 9680 | 6870 | 5100 | 4800 | 88000 |
| DEVIL'S DEN WD | AGR ENT=WT01 | 31A | 254 | 381 | 762 | 1016 | 1270 | 2032 | 2286 | 2286 | 1143 | 508 | 381 | 381 | 12700 |
| DEVIL'S DEN WD | AGR SUR=WT04 | 31A | 1496 | 1349 | 1438 | 364 | 0 | 0 | 774 | 674 | 0 | 0 | 0 | 1205 | 7300 |
| *** TOTAL *** | | | 1750 | 1730 | 2200 | 1380 | 1270 | 2032 | 3060 | 2960 | 1143 | 508 | 381 | 1586 | 20000 |
| DUDLEY RIDGE WD | AGR ENT=WT01 | 8D | 1070 | 1605 | 1900 | 3680 | 8612 | 10000 | 12377 | 7867 | 2189 | 1968 | 730 | 1502 | 53500 |
| DUDLEY RIDGE WD | AGR SUR=WT04 | 8D | 0 | 0 | 0 | 0 | 0 | 1014 | 1125 | 0 | 0 | 0 | 0 | 0 | 2139 |
| *** TOTAL *** | | | 1070 | 1605 | 1900 | 3680 | 8612 | 11014 | 13502 | 7867 | 2189 | 1968 | 730 | 1502 | 55639 |

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EMPIRE WS ID | AGR ENT=WT01 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | AGR SUR=WT04 | 8C | 390 | 160 | 320 | 60 | 0 | 320 | 460 | 460 | 330 | 80 | 260 | 160 | 3000 |
| *** TOTAL *** | | | 450 | 250 | 500 | 300 | 300 | 800 | 1000 | 1000 | 600 | 200 | 350 | 250 | 6000 |
| KERN COUNTY WA | M GW ENT=WT08 | 9 | 0 | 150 | 200 | 0 | 300 | 400 | 500 | 717 | 200 | 200 | 200 | 1166 | 4033 |
| KERN COUNTY WA | AGR ENT=WT01 | 9 | 500 | 3000 | 7300 | 9300 | 10800 | 18900 | 22000 | 20733 | 10200 | 6300 | 5300 | 5300 | 119633 |
| KERN COUNTY WA | AGR SUR=WT04 | 9 | 0 | 0 | 0 | 0 | 500 | 3700 | 4500 | 3300 | 1100 | 0 | 0 | 0 | 13100 |
| KERN COUNTY WA | M&I ENT=WT10 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M GW ENT=WT08 | 10A | 0 | 150 | 500 | 300 | 600 | 700 | 800 | 1117 | 200 | 200 | 200 | 0 | 4767 |
| KERN COUNTY WA | AGR ENT=WT01 | 10A | 442 | 5563 | 18512 | 23985 | 27737 | 36888 | 42152 | 41667 | 8971 | 2093 | 1472 | 1547 | 211029 |
| KERN COUNTY WA | AGR SUR=WT04 | 10A | 0 | 0 | 3316 | 2412 | 5615 | 16924 | 21682 | 18132 | 3819 | 0 | 0 | 0 | 71900 |
| KERN COUNTY WA | M&I ENT=WT10 | 11B | 0 | 0 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 15000 |
| KERN COUNTY WA | AGR ENT=WT01 | 11B | 0 | 0 | 8111 | 7192 | 8852 | 28155 | 33854 | 36459 | 6513 | 2691 | 979 | 815 | 133621 |
| KERN COUNTY WA | M&I ENT=WT10 | 12E | 1490 | 1370 | 1590 | 2190 | 2890 | 3100 | 3390 | 3520 | 2790 | 2310 | 1690 | 1590 | 27920 |
| KERN COUNTY WA | M GW ENT=WT08 | 12E | 550 | 980 | 920 | 1670 | 6940 | 11610 | 9940 | 7440 | 5120 | 6690 | 6970 | 10050 | 68880 |
| KERN COUNTY WA | AGR ENT=WT01 | 12E | 966 | 2999 | 5998 | 9514 | 13430 | 19978 | 20394 | 19986 | 9047 | 3032 | 449 | 249 | 106042 |
| KERN COUNTY WA | AGR SUR=WT04 | 12E | 100 | 200 | 4317 | 4412 | 5115 | 12624 | 13382 | 11557 | 5218 | 0 | 0 | 0 | 56925 |
| KERN COUNTY WA | AGR ENT=WT01 | 13B | 1376 | 988 | 0 | 1008 | 1385 | 7376 | 7443 | 1851 | 773 | 975 | 832 | 7868 | 31875 |
| KERN COUNTY WA | AGR SUR=WT04 | 13B | 1718 | 987 | 541 | 1000 | 1187 | 0 | 0 | 3934 | 0 | 0 | 0 | 0 | 9367 |
| KERN COUNTY WA | M&I ENT=WT10 | 14A | 40 | 40 | 40 | 45 | 45 | 45 | 45 | 40 | 40 | 40 | 40 | 40 | 500 |
| KERN COUNTY WA | AGR ENT=WT01 | 14A | 0 | 0 | 3700 | 1800 | 3700 | 6700 | 7400 | 6700 | 2200 | 1200 | 1200 | 1700 | 36300 |
| KERN COUNTY WA | AGR ENT=WT01 | 14B | 0 | 0 | 10420 | 6420 | 10420 | 14420 | 15420 | 14420 | 4420 | 3420 | 2920 | 2420 | 84700 |
| KERN COUNTY WA | AGR ENT=WT01 | 14C | 0 | 0 | 4830 | 3330 | 4830 | 7330 | 7330 | 7330 | 3330 | 2830 | 2330 | 3330 | 46800 |
| KERN COUNTY WA | AGR ENT=WT01 | 15A | 0 | 0 | 3000 | 3600 | 3000 | 6000 | 7400 | 6600 | 2500 | 3000 | 3500 | 4000 | 42600 |
| KERN COUNTY WA | M&I ENT=WT10 | 16A | 0 | 0 | 0 | 300 | 500 | 500 | 500 | 500 | 500 | 0 | 0 | 0 | 2800 |
| KERN COUNTY WA | AGR ENT=WT01 | 16A | 0 | 0 | 1000 | 1900 | 1200 | 1700 | 2350 | 1850 | 1700 | 1600 | 1000 | 1500 | 15800 |
| KERN COUNTY WA | AGR ENT=WT01 | 31A | 0 | 0 | 4300 | 11000 | 17500 | 20700 | 24800 | 24700 | 8000 | 1700 | 3900 | 5700 | 122300 |
| *** TOTAL *** | | | 7182 | 16427 | 80095 | 92878 | 128046 | 219250 | 246782 | 234053 | 78141 | 39781 | 34482 | 48775 | 1225892 |
| COUNTY OF KINGS | M&I ENT=WT10 | 8C | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| *** TOTAL *** | | | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| OAK FLAT WD | AGR ENT=WT01 | 2A | 0 | 162 | 324 | 594 | 648 | 864 | 972 | 972 | 486 | 216 | 162 | 0 | 5400 |
| OAK FLAT WD | AGR SUR=WT04 | 2A | 0 | 50 | 200 | 400 | 600 | 310 | 340 | 0 | 0 | 0 | 0 | 0 | 1900 |
| *** TOTAL *** | | | 0 | 212 | 524 | 994 | 1248 | 1174 | 1312 | 972 | 486 | 216 | 162 | 0 | 7300 |
| TULARE LK BWSD | AGR ENT=WT01 | 8C | 3000 | 5000 | 3000 | 5000 | 2000 | 8000 | 7000 | 8000 | 1000 | 2000 | 4000 | 8000 | 56000 |
| TULARE LK BWSD | WET WTHR=WT07 | 8C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5900 | 5900 |
| TULARE LK BWSD | AGR SUR=WT04 | 8C | 6888 | 4832 | 4664 | 4552 | 6440 | 7104 | 6992 | 6992 | 496 | 776 | 2832 | 6932 | 59500 |
| TULARE LK BWSD | AGR ENT=WT01 | 8D | 1000 | 4000 | 3000 | 3000 | 1000 | 9000 | 9000 | 9000 | 600 | 2000 | 3000 | 5000 | 49600 |
| TULARE LK BWSD | WET WTHR=WT07 | 8D | 0 | 0 | 0 | 0 | 0 | 1000 | 0 | 0 | 1000 | 0 | 0 | 5000 | 7000 |
| TULARE LK BWSD | AGR SUR=WT04 | 8D | 3000 | 3000 | 0 | 0 | 2000 | 6000 | 13000 | 11000 | 1000 | 0 | 2000 | 6000 | 47000 |
| *** TOTAL *** | | | 13888 | 16832 | 10664 | 12552 | 11440 | 31104 | 35992 | 34992 | 4096 | 4776 | 11832 | 36832 | 225000 |
| AVEK WA | M&I ENT=WT10 | 19 | 200 | 160 | 200 | 320 | 400 | 400 | 480 | 600 | 400 | 320 | 320 | 200 | 4000 |
| AVEK WA | AGR ENT=WT01 | 19 | 19 | 469 | 1139 | 2165 | 3160 | 3180 | 3970 | 4390 | 1625 | 485 | 48 | 0 | 20650 |
| AVEK WA | M&I ENT=WT10 | 20A | 900 | 720 | 900 | 1440 | 1800 | 1800 | 2160 | 2700 | 1800 | 1440 | 1440 | 900 | 18000 |
| AVEK WA | AGR ENT=WT01 | 20A | 1 | 1 | 1 | 10 | 15 | 20 | 30 | 30 | 25 | 15 | 2 | 0 | 150 |
| AVEK WA | M&I ENT=WT10 | 22A | 100 | 80 | 100 | 160 | 200 | 200 | 240 | 300 | 200 | 160 | 160 | 100 | 2000 |
| AVEK WA | AGR ENT=WT01 | 22A | 30 | 30 | 110 | 125 | 125 | 150 | 150 | 180 | 150 | 100 | 50 | 0 | 1200 |
| *** TOTAL *** | | | 1250 | 1460 | 2450 | 4220 | 5700 | 5750 | 7030 | 8200 | 4200 | 2520 | 2020 | 1200 | 46000 |

FILE DUMP

FILE IDENTIFICATION: R198888 02/16/88. SHEET 3

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CASTAIC LAKE WA | M&I ENT=WT10 | 30 | 1104 | 1104 | 1288 | 1472 | 1840 | 1840 | 2208 | 2208 | 1656 | 1472 | 1104 | 1104 | 18400 |
| *** TOTAL *** | | | 1104 | 1104 | 1288 | 1472 | 1840 | 1840 | 2208 | 2208 | 1656 | 1472 | 1104 | 1104 | 18400 |
| COACHELLA VALLY | M GW ENT=WT08 | 26A | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 20652 |
| *** TOTAL *** | | | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 1721 | 20652 |
| CRESTLINE-LA WA | M&I ENT=WT10 | 24 | 143 | 124 | 105 | 105 | 152 | 171 | 220 | 300 | 220 | 160 | 160 | 140 | 2000 |
| *** TOTAL *** | | | 143 | 124 | 105 | 105 | 152 | 171 | 220 | 300 | 220 | 160 | 160 | 140 | 2000 |
| DESERT WA | M&I ENT=WT10 | 26A | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2837 | 34000 |
| *** TOTAL *** | | | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2833 | 2837 | 34000 |
| LITTLEROCK CR | M&I ENT=WT10 | 21 | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 100 |
| LITTLEROCK CR | AGR ENT=WT01 | 21 | 0 | 0 | 217 | 217 | 217 | 192 | 192 | 192 | 192 | 217 | 217 | 0 | 1853 |
| LITTLEROCK CR | M&I ENT=WT10 | 22A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 217 | 217 | 217 | 217 | 217 | 217 | 217 | 217 | 217 | 0 | 1953 |
| METROPOLITAN WD | M&I ENT=WT10 | 26A | 246 | 5246 | 4646 | 9446 | 14246 | 17046 | 24546 | 19946 | 13646 | 14046 | 15046 | 5042 | 143148 |
| METROPOLITAN WD | M GW ENT=WT08 | 26A | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 | 3000 | 3000 | 8000 | 8000 | 8000 | 8000 | 86000 |
| METROPOLITAN WD | M&I ENT=WT10 | 28H | 2000 | 2000 | 3200 | 3600 | 4000 | 5700 | 6900 | 6500 | 5200 | 4400 | 2400 | 2400 | 48300 |
| METROPOLITAN WD | BYPS ENT=WT59 | 28H | 4800 | 9800 | 9200 | 14000 | 18800 | 21700 | 23000 | 23000 | 18200 | 18600 | 19600 | 9600 | 190300 |
| METROPOLITAN WD | M&I ENT=WT10 | 28J | 400 | 400 | 400 | 400 | 400 | 13000 | 13000 | 13000 | 400 | 400 | 400 | 400 | 42600 |
| METROPOLITAN WD | M&I ENT=WT10 | 30 | 35000 | 35000 | 40000 | 40000 | 45000 | 48000 | 48000 | 48000 | 48000 | 45000 | 42000 | 42000 | 516000 |
| *** TOTAL *** | | | 50446 | 60446 | 65446 | 75446 | 90446 | 113446 | 118446 | 113446 | 93446 | 90446 | 87446 | 67442 | 1026348 |
| MOJAVE WA | M&I ENT=WT10 | 22B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PALMDALE WD | M&I ENT=WT10 | 20A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PALMDALE WD | M&I ENT=WT10 | 20B | 0 | 0 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 0 | 6210 |
| *** TOTAL *** | | | 0 | 0 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 690 | 0 | 6210 |
| SAN BERNARDINO | M&I ENT=WT10 | 26A | 0 | 0 | 0 | 0 | 1600 | 1600 | 1600 | 1600 | 1600 | 1600 | 0 | 0 | 9600 |
| SAN BERNARDINO | M GW ENT=WT08 | 26A | 1400 | 1400 | 1400 | 1400 | 1400 | 1400 | 1000 | 1000 | 1000 | 1000 | 1000 | 0 | 13400 |
| *** TOTAL *** | | | 1400 | 1400 | 1400 | 1400 | 3000 | 3000 | 2600 | 2600 | 2600 | 2600 | 1000 | 0 | 23000 |
| SAN GABRIEL | M GW ENT=WT08 | 26A | 0 | 0 | 0 | 0 | 2100 | 2100 | 2100 | 2100 | 2100 | 0 | 0 | 0 | 10500 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 2100 | 2100 | 2100 | 2100 | 2100 | 0 | 0 | 0 | 10500 |
| VENTURA CO FCD | M&I ENT=WT10 | 29H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| VENTURA CO FCD | M&I ENT=WT10 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SHELL CAL PROD. | REPAYMNT=WT09 | 11B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 585 | 840 | 870 | 2295 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 585 | 840 | 870 | 2295 |

STATE OF CALIFORNIA
THE RESOURCES AGENCY

FILE ID: Q198989

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1989

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

DATE: 12/22/88
PAGE: 1

1989

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE TOTAL = | 1200 | M&I ENT = | 1200 | | | | | |
| PLUMAS CO FCWCD TOTAL = | 1000 | M&I ENT = | 1000 | | | | | |
| YUBA CITY TOTAL = | 1500 | M&I ENT = | 1500 | | | | | |
| NAPA CO FCWCD TOTAL = | 6166 | M&I ENT = | 6166 | | | | | |
| SOLANO CO FCWCD TOTAL = | 28235 | | | | | | | |
| TOT ENT = | 18420 | M&I ENT = | 1300 | BEN ENT = | 11220 | VAL ENT = | 5900 | |
| TOT MISC = | 9815 | VAL PMT = | 9815 | | | | | |
| ZONE-7 ALAMEDA TOTAL = | 31000 | | | | | | | |
| TOT ENT = | 31000 | M&I ENT = | 22301 | M GW ENT = | 6419 | AGR ENT = | 2280 | |
| ALAMEDA CO WD TOTAL = | 35700 | | | | | | | |
| TOT ENT = | 35700 | M&I ENT = | 9700 | M GW ENT = | 24450 | A GW ENT = | 1550 | |
| SANTA CLARA VWD TOTAL = | 90000 | | | | | | | |
| TOT ENT = | 90000 | M&I ENT = | 86400 | M GW ENT = | 3600 | | | |
| DEVIL'S DEN WD TOTAL = | 20000 | | | | | | | |
| | | AGR ENT = | 12700 | | | | | |
| | | AGR SUR = | 7300 | | | | | |
| DUDLEY RIDGE WD TOTAL = | 65167 | | | | | | | |
| | | AGR ENT = | 55600 | | | | | |
| | | CYOV ENT = | 9567 | | | | | |
| EMPIRE WS ID TOTAL = | 6000 | | | | | | | |
| | | AGR ENT = | 3000 | | | | | |
| | | AGR SUR = | 3000 | | | | | |
| KERN COUNTY WA TOTAL = | 1188805 | | | | | | | |
| TOT ENT = | 1112300 | M&I ENT = | 56318 | M GW ENT = | 76882 | AGR ENT = | 979100 | |
| TOT MISC = | 76505 | CYOV ENT = | 76505 | | | | | |
| COUNTY OF KINGS TOTAL = | 4000 | M&I ENT = | 4000 | | | | | |
| OAK FLAT WD TOTAL = | 7900 | | | | | | | |
| | | AGR ENT = | 5600 | | | | | |
| | | AGR SUR = | 1900 | | | | | |
| | | CYOV ENT = | 400 | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TULARE LK BWSD | TOTAL = | 373600 | | | | | |
| | | | AGR ENT = | 109900 | | | |
| | | | AGR SUR = | 233500 | | | |
| | TOT MISC = | 30200 | WET WTHR = | 8600 | CYOV ENT = | 21600 | |
| AVEK WA | TOTAL = | 55000 | | | | | |
| | TOT ENT = | 55000 | M^I ENT = | 31390 | AGR ENT = | 23610 | |
| CASTAIC LAKE WA | TOTAL = | 24480 | | | | | |
| | | | M^I ENT = | 24480 | | | |
| COACHELLA VALLY | TOTAL = | 21873 | | | | | |
| | | | M GW ENT = | 21873 | | | |
| CRESTLINE-LA WA | TOTAL = | 2465 | | | | | |
| | | | M^I ENT = | 2465 | | | |
| DESERT WA | TOTAL = | 36500 | | | | | |
| | | | M^I ENT = | 36500 | | | |
| LITTLEROCK CR | TOTAL = | 2070 | | | | | |
| | | | M^I ENT = | 2070 | | | |
| METROPOLITAN WD | TOTAL = | 1312627 | | | | | |
| | TOT ENT = | 1312627 | M^I ENT = | 949127 | M GW ENT = | 100000 | BYPS ENT = 263500 |
| MOJAVE WA | TOTAL = | 360 | | | | | |
| | | | M^I ENT = | 360 | | | |
| PALMDALE WD | TOTAL = | 8190 | | | | | |
| | | | M^I ENT = | 8190 | | | |
| SAN BERNARDINO | TOTAL = | 34800 | | | | | |
| | TOT ENT = | 34800 | M^I ENT = | 10800 | M GW ENT = | 24000 | |
| SAN GABRIEL | TOTAL = | 13000 | | | | | |
| | | | M GW ENT = | 13000 | | | |
| SHELL CAL PROD. | TOTAL = | 4298 | | | | | |
| | | | REPAYMNT = | 4298 | | | |
| JG BOSWELL | TOTAL = | 8000 | | | | | |
| | | | REPAYMNT = | 8000 | | | |
| FISH ^ GAME | TOTAL = | 1200 | | | | | |
| | | | REC/F^WL = | 1200 | | | |
| PARKS ^ RECREAT | TOTAL = | 163 | | | | | |
| | | | REC/F^WL = | 163 | | | |

FILE DUMP

FILE IDENTIFICATION: Q198989 12/22/88. SHEET 1

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M^I ENT=WT10 | FR | 50 | 50 | 120 | 70 | 70 | 90 | 170 | 200 | 170 | 90 | 60 | 60 | 1200 |
| *** TOTAL *** | | | 50 | 50 | 120 | 70 | 70 | 90 | 170 | 200 | 170 | 90 | 60 | 60 | 1200 |
| PLUMAS CO FCWCD | M^I ENT=WT10 | FR | 25 | 30 | 41 | 75 | 99 | 144 | 159 | 159 | 159 | 40 | 35 | 34 | 1000 |
| *** TOTAL *** | | | 25 | 30 | 41 | 75 | 99 | 144 | 159 | 159 | 159 | 40 | 35 | 34 | 1000 |
| YUBA CITY | M^I ENT=WT10 | FR | 0 | 0 | 0 | 0 | 0 | 0 | 500 | 600 | 300 | 100 | 0 | 0 | 1500 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 500 | 600 | 300 | 100 | 0 | 0 | 1500 |
| NAPA CO FCWCD | M^I ENT=WT10 | 3NB | 508 | 501 | 549 | 574 | 517 | 410 | 442 | 444 | 556 | 633 | 519 | 513 | 6166 |
| *** TOTAL *** | | | 508 | 501 | 549 | 574 | 517 | 410 | 442 | 444 | 556 | 633 | 519 | 513 | 6166 |
| SOLANO CO FCWCD | M^I ENT=WT10 | 1NB | 100 | 100 | 100 | 100 | 125 | 125 | 125 | 125 | 100 | 100 | 100 | 100 | 1300 |
| SOLANO CO FCWCD | VAL PMT =WT71 | 1NB | 25 | 25 | 25 | 85 | 150 | 245 | 275 | 275 | 210 | 120 | 55 | 25 | 1515 |
| SOLANO CO FCWCD | BEN ENT =WT46 | 3NA | 816 | 643 | 830 | 962 | 1037 | 946 | 1101 | 1091 | 1037 | 1009 | 937 | 811 | 11220 |
| SOLANO CO FCWCD | VAL ENT =WT47 | 3NA | 483 | 483 | 483 | 483 | 509 | 509 | 509 | 509 | 483 | 483 | 483 | 483 | 5900 17,120 |
| SOLANO CO FCWCD | VAL PMT =WT71 | 3NA | 250 | 250 | 250 | 700 | 975 | 1025 | 1250 | 1250 | 950 | 700 | 350 | 350 | 8300 |
| *** TOTAL *** | | | 1674 | 1501 | 1688 | 2330 | 2796 | 2850 | 3260 | 3250 | 2780 | 2412 | 1925 | 1769 | 28235 |
| ZONE-7 ALAMEDA | M^I ENT=WT10 | 1SB | 3 | 2 | 2 | 8 | 21 | 30 | 34 | 36 | 29 | 20 | 7 | 3 | 195 |
| ZONE-7 ALAMEDA | M^I ENT=WT10 | 2SB | 428 | 400 | 483 | 644 | 956 | 1127 | 1261 | 1196 | 881 | 647 | 407 | 413 | 8843 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 4SB | 267 | 267 | 267 | 267 | 269 | 270 | 270 | 270 | 267 | 267 | 267 | 267 | 3215 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 4SB | 1 | 1 | 83 | 217 | 380 | 397 | 407 | 368 | 12 | 107 | 1 | 1 | 1975 5190 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 5SB | 267 | 267 | 267 | 267 | 267 | 267 | 267 | 267 | 267 | 267 | 267 | 267 | 3204 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 5SB | 0 | 0 | 0 | 10 | 40 | 40 | 40 | 20 | 0 | 10 | 0 | 0 | 160 |
| ZONE-7 ALAMEDA | M^I ENT=WT10 | 6SB | 641 | 600 | 724 | 966 | 1434 | 1690 | 1892 | 1794 | 1321 | 970 | 611 | 620 | 13263 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 6SB | 0 | 0 | 0 | 5 | 35 | 20 | 45 | 35 | 5 | 0 | 0 | 0 | 145 |
| *** TOTAL *** | | | 1607 | 1537 | 1826 | 2384 | 3402 | 3841 | 4216 | 3986 | 2782 | 2288 | 1560 | 1571 | 31000 |
| ALAMEDA CO WD | M GW ENT=WT08 | 7SB | 2150 | 2010 | 2150 | 2180 | 2260 | 2180 | 2260 | 2260 | 2180 | 1950 | 1340 | 1530 | 24450 |
| ALAMEDA CO WD | A GW ENT=WT22 | 7SB | 0 | 0 | 0 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 150 | 0 | 1550 |
| ALAMEDA CO WD | WET WTHR=WT07 | 7SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ALAMEDA CO WD | M^I ENT=WT10 | 8SB | 827 | 747 | 827 | 800 | 827 | 800 | 827 | 827 | 800 | 827 | 800 | 791 | 9700 |
| *** TOTAL *** | | | 2977 | 2757 | 2977 | 3180 | 3287 | 3180 | 3287 | 3287 | 3180 | 2977 | 2290 | 2321 | 35700 |
| SANTA CLARA VWD | M^I ENT=WT10 | 9SB | 5000 | 3700 | 5800 | 6500 | 6700 | 8000 | 9000 | 9000 | 9000 | 8300 | 7800 | 7600 | 86400 |
| SANTA CLARA VWD | M GW ENT=WT08 | 9SB | 200 | 200 | 200 | 0 | 800 | 500 | 0 | 500 | 400 | 400 | 200 | 200 | 3600 |
| *** TOTAL *** | | | 5200 | 3900 | 6000 | 6500 | 7500 | 8500 | 9000 | 9500 | 9400 | 8700 | 8000 | 7800 | 90000 |
| DEVIL↑S DEN WD | AGR ENT=WT01 | 31A | 254 | 381 | 762 | 1016 | 1270 | 2032 | 2286 | 2286 | 1143 | 508 | 381 | 381 | 12700 |
| DEVIL↑S DEN WD | AGR SUR=WT04 | 31A | 1496 | 1349 | 1438 | 364 | 0 | 0 | 774 | 674 | 0 | 0 | 0 | 1205 | 7300 |
| *** TOTAL *** | | | 1750 | 1730 | 2200 | 1380 | 1270 | 2032 | 3060 | 2960 | 1143 | 508 | 381 | 1586 | 20000 |
| DUDLEY RIDGE WD | AGR ENT=WT01 | 8D | 0 | 0 | 3675 | 2937 | 6499 | 10613 | 12990 | 11415 | 2560 | 2548 | 1020 | 1343 | 55600 |
| DUDLEY RIDGE WD | CYOV ENT=WT69 | 8D | 4089 | 5478 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9567 |
| *** TOTAL *** | | | 4089 | 5478 | 3675 | 2937 | 6499 | 10613 | 12990 | 11415 | 2560 | 2548 | 1020 | 1343 | 65167 |

FILE DUMP

FILE IDENTIFICATION: Q198989 12/22/88. SHEET 2

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EMPIRE WS ID | AGR ENT=WT01 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | AGR SUR=WT04 | 8C | 390 | 160 | 320 | 60 | 0 | 320 | 460 | 460 | 330 | 80 | 260 | 160 | 3000 |
| *** TOTAL *** | | | 450 | 250 | 500 | 300 | 300 | 800 | 1000 | 1000 | 600 | 200 | 350 | 250 | 6000 |
| KERN COUNTY WA | AGR ENT=WT01 | 9 | 50 | 50 | 5100 | 8100 | 10200 | 16200 | 16200 | 15200 | 10100 | 4000 | 3000 | 3000 | 91200 |
| KERN COUNTY WA | CYOV ENT=WT69 | 9 | 3000 | 4325 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7325 |
| KERN COUNTY WA | M^I ENT=WT10 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M GW ENT=WT08 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2700 | 0 | 0 | 0 | 0 | 2700 |
| KERN COUNTY WA | AGR ENT=WT01 | 10A | 3289 | 3664 | 7049 | 15117 | 39053 | 49281 | 47849 | 44703 | 23502 | 4526 | 4128 | 4707 | 246868 |
| KERN COUNTY WA | CYOV ENT=WT69 | 10A | 1000 | 13000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14000 |
| KERN COUNTY WA | AGR SUR=WT04 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M^I ENT=WT10 | 11B | 1666 | 1667 | 1666 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1666 | 1666 | 1667 | 20000 |
| KERN COUNTY WA | AGR ENT=WT01 | 11B | 0 | 0 | 6801 | 7323 | 22255 | 22490 | 22173 | 32149 | 7520 | 4163 | 2391 | 2758 | 130023 |
| KERN COUNTY WA | CYOV ENT=WT69 | 11B | 4000 | 7000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11000 |
| KERN COUNTY WA | M^I ENT=WT10 | 12E | 0 | 0 | 0 | 0 | 7890 | 8624 | 10202 | 5802 | 0 | 1000 | 0 | 0 | 33518 |
| KERN COUNTY WA | M GW ENT=WT08 | 12E | 1778 | 2967 | 5734 | 6312 | 1500 | 16900 | 12700 | 7300 | 9101 | 2156 | 2367 | 2367 | 71182 |
| KERN COUNTY WA | AGR ENT=WT01 | 12E | 4578 | 7078 | 10128 | 11328 | 17128 | 26428 | 25278 | 24766 | 18188 | 3828 | 3428 | 3328 | 155484 |
| KERN COUNTY WA | CYOV ENT=WT69 | 12E | 7500 | 12000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19500 |
| KERN COUNTY WA | AGR SUR=WT04 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M GW ENT=WT08 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3000 | 0 | 0 | 0 | 0 | 3000 |
| KERN COUNTY WA | AGR ENT=WT01 | 13B | 0 | 0 | 625 | 2330 | 1675 | 7930 | 8962 | 5200 | 225 | 1400 | 998 | 4280 | 33625 |
| KERN COUNTY WA | CYOV ENT=WT69 | 13B | 930 | 750 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1680 |
| KERN COUNTY WA | AGR SUR=WT04 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M^I ENT=WT10 | 14A | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 63 | 800 |
| KERN COUNTY WA | AGR ENT=WT01 | 14A | 1000 | 1500 | 3700 | 2800 | 4600 | 7500 | 8200 | 7500 | 1100 | 1100 | 500 | 600 | 40100 |
| KERN COUNTY WA | CYOV ENT=WT69 | 14A | 540 | 960 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1500 |
| KERN COUNTY WA | AGR ENT=WT01 | 14B | 1000 | 1500 | 9300 | 7300 | 10700 | 13000 | 11000 | 12000 | 3500 | 1700 | 1300 | 1500 | 73800 |
| KERN COUNTY WA | CYOV ENT=WT69 | 14B | 2220 | 3000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5220 |
| KERN COUNTY WA | AGR ENT=WT01 | 14C | 1000 | 2000 | 4200 | 2700 | 4300 | 6500 | 8000 | 6600 | 1500 | 1000 | 500 | 1000 | 39300 |
| KERN COUNTY WA | CYOV ENT=WT69 | 14C | 1740 | 2880 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4620 |
| KERN COUNTY WA | AGR ENT=WT01 | 15A | 500 | 500 | 3600 | 4300 | 3300 | 7000 | 8800 | 7000 | 2500 | 1800 | 1200 | 1550 | 42050 |
| KERN COUNTY WA | CYOV ENT=WT69 | 15A | 900 | 1500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2400 |
| KERN COUNTY WA | M^I ENT=WT10 | 16A | 0 | 0 | 0 | 0 | 291 | 382 | 394 | 394 | 369 | 170 | 0 | 0 | 2000 |
| KERN COUNTY WA | AGR ENT=WT01 | 16A | 500 | 500 | 1200 | 2000 | 1400 | 2300 | 2300 | 2200 | 1700 | 1500 | 500 | 550 | 16650 |
| KERN COUNTY WA | CYOV ENT=WT69 | 16A | 600 | 660 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1260 |
| KERN COUNTY WA | AGR ENT=WT01 | 31A | 0 | 0 | 7300 | 14000 | 17000 | 17000 | 17000 | 18100 | 8000 | 4300 | 3500 | 3800 | 110000 |
| KERN COUNTY WA | CYOV ENT=WT69 | 31A | 4000 | 4000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8000 |
| KERN COUNTY WA | AGR SUR=WT04 | 31A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 41858 | 71568 | 66470 | 85344 | 143026 | 203269 | 200792 | 196348 | 89039 | 34376 | 25545 | 31170 | 1188805 |
| COUNTY OF KINGS | M^I ENT=WT10 | 8C | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| *** TOTAL *** | | | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| OAK FLAT WD | AGR ENT=WT01 | 2A | 0 | 168 | 336 | 616 | 672 | 896 | 1008 | 1008 | 504 | 224 | 168 | 0 | 5600 |
| OAK FLAT WD | CYOV ENT=WT69 | 2A | 200 | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 400 |
| OAK FLAT WD | AGR SUR=WT04 | 2A | 0 | 57 | 211 | 400 | 600 | 300 | 332 | 0 | 0 | 0 | 0 | 0 | 1900 |
| *** TOTAL *** | | | 200 | 425 | 547 | 1016 | 1272 | 1196 | 1340 | 1008 | 504 | 224 | 168 | 0 | 7900 |
| TULARE LK BWSD | AGR ENT=WT01 | 8C | 625 | 396 | 1500 | 1400 | 4079 | 8142 | 7527 | 7584 | 4729 | 1300 | 1750 | 5768 | 44800 |
| TULARE LK BWSD | WET WTHR=WT07 | 8C | 26 | 730 | 750 | 220 | 0 | 0 | 262 | 53 | 0 | 0 | 359 | 0 | 2400 |
| TULARE LK BWSD | CYOV ENT=WT69 | 8C | 5300 | 5300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10600 |
| TULARE LK BWSD | AGR SUR=WT04 | 8C | 14000 | 13500 | 7700 | 3400 | 900 | 11800 | 12100 | 12300 | 5200 | 3700 | 2900 | 14000 | 101500 |

98,525

268,868

104,700

174,984

35,305

57,000

FILE DUMP

FILE IDENTIFICATION: Q198989 12/22/88. SHEET 3

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TULARE LK BWSD | AGR ENT=WT01 | 8D | 0 | 1875 | 0 | 400 | 1875 | 11300 | 12250 | 12198 | 7438 | 0 | 3750 | 14014 | 65100 |
| TULARE LK BWSD | WET WTHR=WT07 | 8D | 0 | 1951 | 2250 | 375 | 0 | 0 | 275 | 275 | 0 | 0 | 1074 | 0 | 6200 |
| TULARE LK BWSD | CYOV ENT=WT69 | 8D | 5500 | 5500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11000 |
| TULARE LK BWSD | AGR SUR=WT04 | 8D | 21300 | 17500 | 11100 | 5900 | 4800 | 15500 | 14200 | 14300 | 6000 | 6700 | 1900 | 12800 | 132000 |
| *** TOTAL *** | | | 46751 | 46752 | 23300 | 11695 | 11654 | 46742 | 46614 | 46710 | 23367 | 11700 | 11733 | 46582 | 373600 |
| AVEK WA | M^I ENT=WT10 | 19 | 170 | 300 | 350 | 400 | 450 | 500 | 575 | 575 | 500 | 400 | 250 | 225 | 4695 |
| AVEK WA | AGR ENT=WT01 | 19 | 5 | 305 | 1885 | 2920 | 3080 | 3190 | 3500 | 3500 | 2180 | 1475 | 335 | 25 | 22400 |
| AVEK WA | M^I ENT=WT10 | 20A | 1275 | 1150 | 1300 | 1800 | 2225 | 2500 | 2800 | 3025 | 2200 | 1800 | 1650 | 1275 | 23000 |
| AVEK WA | AGR ENT=WT01 | 20A | 2 | 3 | 5 | 15 | 20 | 25 | 35 | 35 | 30 | 15 | 3 | 2 | 190 |
| AVEK WA | M^I ENT=WT10 | 20B | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 60 |
| AVEK WA | M^I ENT=WT10 | 22A | 195 | 210 | 250 | 290 | 320 | 365 | 430 | 430 | 410 | 325 | 220 | 190 | 3635 |
| AVEK WA | AGR ENT=WT01 | 22A | 20 | 20 | 100 | 100 | 150 | 150 | 150 | 150 | 100 | 50 | 20 | 10 | 1020 |
| *** TOTAL *** | | | 1672 | 1993 | 3895 | 5530 | 6250 | 6735 | 7495 | 7720 | 5425 | 4070 | 2483 | 1732 | 55000 |
| CASTAIC LAKE WA | M^I ENT=WT10 | 30 | 1415 | 1415 | 1650 | 1986 | 2458 | 2458 | 2930 | 2930 | 2222 | 1986 | 1515 | 1515 | 24480 |
| *** TOTAL *** | | | 1415 | 1415 | 1650 | 1986 | 2458 | 2458 | 2930 | 2930 | 2222 | 1986 | 1515 | 1515 | 24480 |
| COACHELLA VALLY | M GW ENT=WT08 | 26A | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1831 | 21873 |
| *** TOTAL *** | | | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1822 | 1831 | 21873 |
| CRESTLINE-LA WA | M^I ENT=WT10 | 24 | 227 | 133 | 133 | 137 | 184 | 207 | 265 | 362 | 265 | 192 | 192 | 168 | 2465 |
| *** TOTAL *** | | | 227 | 133 | 133 | 137 | 184 | 207 | 265 | 362 | 265 | 192 | 192 | 168 | 2465 |
| DESERT WA | M^I ENT=WT10 | 26A | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3049 | 36500 |
| *** TOTAL *** | | | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3041 | 3049 | 36500 |
| LITTLEROCK CR | M^I ENT=WT10 | 21 | 0 | 0 | 230 | 230 | 230 | 230 | 230 | 230 | 230 | 230 | 230 | 0 | 2070 |
| LITTLEROCK CR | AGR ENT=WT01 | 21 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 230 | 230 | 230 | 230 | 230 | 230 | 230 | 230 | 230 | 0 | 2070 |
| METROPOLITAN WD | M^I ENT=WT10 | 26A | 24837 | 20337 | 8637 | 15437 | 21637 | 16537 | 18537 | 19037 | 23037 | 20437 | 17657 | 0 | 206127 |
| METROPOLITAN WD | M GW ENT=WT08 | 26A | 8000 | 12000 | 15000 | 15000 | 12000 | 8000 | 3000 | 3000 | 8000 | 8000 | 8000 | 0 | 100000 |
| METROPOLITAN WD | M^I ENT=WT10 | 28H | 2200 | 2200 | 3600 | 4000 | 4500 | 6200 | 7600 | 7100 | 5800 | 4900 | 2700 | 2700 | 53500 |
| METROPOLITAN WD | BYPS ENT=WT59 | 28H | 29700 | 25200 | 13500 | 20300 | 26600 | 21400 | 23000 | 23000 | 27900 | 25400 | 27500 | 0 | 263500 |
| METROPOLITAN WD | M^I ENT=WT10 | 28J | 400 | 400 | 400 | 400 | 400 | 13000 | 13000 | 13000 | 400 | 400 | 400 | 13300 | 55500 |
| METROPOLITAN WD | M^I ENT=WT10 | 30 | 0 | 60000 | 60000 | 60000 | 50000 | 50000 | 60000 | 60000 | 60000 | 60000 | 60000 | 54000 | 634000 |
| *** TOTAL *** | | | 65137 | 120137 | 101137 | 115137 | 115137 | 115137 | 125137 | 125137 | 125137 | 119137 | 116257 | 70000 | 1312627 |
| MOJAVE WA | M^I ENT=WT10 | 22B | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 60 | 60 | 60 | 60 | 60 | 360 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 60 | 60 | 60 | 60 | 60 | 360 |
| PALMDALE WD | M^I ENT=WT10 | 20A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PALMDALE WD | M^I ENT=WT10 | 20B | 0 | 0 | 910 | 910 | 910 | 910 | 910 | 910 | 910 | 910 | 910 | 0 | 8190 |
| *** TOTAL *** | | | 0 | 0 | 910 | 910 | 910 | 910 | 910 | 910 | 910 | 910 | 910 | 0 | 8190 |

57200
83300
141100
82,300

306,127
317,000

STATE OF CALIFORNIA
THE RESOURCES AGENCY

FILE ID: P199090

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1990

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

DATE: 12/15/89
PAGE: 1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE TOTAL = | 1200 | | | | | | |
| | | M&I ENT = | 1200 | | | | |
| PLUMAS CO FCWCD TOTAL = | 1038 | | | | | | |
| | | M&I ENT = | 1038 | | | | |
| YUBA CITY TOTAL = | 1800 | | | | | | |
| | | M&I ENT = | 1800 | | | | |
| NAPA CO FCWCD TOTAL = | 6387 | | | | | | |
| | | M&I ENT = | 6387 | | | | |
| SOLANO CO FCWCD TOTAL = | 30500 | | | | | | |
| TOT ENT = | 21250 | M&I ENT = | 5850 | BEN ENT = | 11600 | VAL ENT = | 3800 |
| TOT MISC = | 9250 | VAL PMT = | 9250 | | | | |
| ZONE-7 ALAMEDA TOTAL = | 32000 | | | | | | |
| TOT ENT = | 32000 | M&I ENT = | 25242 | M GW ENT = | 4520 | AGR ENT = | 2238 |
| ALAMEDA CO WD TOTAL = | 42000 | | | | | | |
| TOT ENT = | 36900 | M&I ENT = | 9700 | M GW ENT = | 26150 | A GW ENT = | 1050 |
| TOT MISC = | 5100 | WET WTHR = | 5100 | | | | |
| SANTA CLARA VWD TOTAL = | 122830 | | | | | | |
| TOT ENT = | 92000 | M&I ENT = | 72200 | M GW ENT = | 19800 | | |
| TOT MISC = | 30830 | PURCHASD = | 30830 | | | | |
| DEVIL'S DEN WD TOTAL = | 20000 | | | | | | |
| | | AGR ENT = | 12700 | | | | |
| | | AGR SUR = | 7300 | | | | |
| DUDLEY RIDGE WD TOTAL = | 66507 | | | | | | |
| | | AGR ENT = | 57700 | | | | |
| | | CYOV ENT = | 8807 | | | | |
| EMPIRE WS ID TOTAL = | 7942 | | | | | | |
| | | AGR ENT = | 3000 | | | | |
| | | AGR SUR = | 3000 | | | | |
| | | TRANSFER = | 1942 | | | | |
| KERN COUNTY WA TOTAL = | 1217081 | | | | | | |
| TOT ENT = | 1153400 | M&I ENT = | 51086 | M GW ENT = | 83610 | AGR ENT = | 1018704 |
| TOT MISC = | 63681 | CYOV ENT = | 63681 | | | | |
| COUNTY OF KINGS TOTAL = | 4000 | | | | | | |
| | | M&I ENT = | 4000 | | | | |
| OAK FLAT WD TOTAL = | 7700 | | | | | | |
| | | AGR ENT = | 5700 | | | | |
| | | AGR SUR = | 2000 | | | | |

190

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TULARE LK BWSD | TOTAL = | 156802 | AGR ENT = | 118500 | | | | | | | |
| | | | PURCHASD = | 38302 | | | | | | | |
| AVEK WA | TOTAL = | 55000 | | | | | | | | | |
| | TOT ENT = | 55000 | M&I ENT = | 31390 | AGR ENT = | 23610 | | | | | |
| CASTAIC LAKE WA | TOTAL = | 22550 | M&I ENT = | 22550 | | | | | | | |
| COACHELLA VALLY | TOTAL = | 23100 | M GW ENT = | 23100 | | | | | | | |
| CRESTLINE-LA WA | TOTAL = | 2665 | M&I ENT = | 2665 | | | | | | | |
| DESERT WA | TOTAL = | 38100 | M&I ENT = | 38100 | | | | | | | |
| LITTLEROCK CR | TOTAL = | 2300 | | | | | | | | | |
| | TOT ENT = | 2300 | M&I ENT = | 1716 | AGR ENT = | 584 | | | | | |
| METROPOLITAN WD | TOTAL = | 1463800 | | | | | | | | | |
| | TOT ENT = | 1463800 | M&I ENT = | 1052300 | M GW ENT = | 100000 | BYPS ENT = | 191500 | STOR ENT = | 120000 | |
| MOJAVE WA | TOTAL = | 360 | M&I ENT = | 360 | | | | | | | |
| PALMDALE WD | TOTAL = | 10440 | M&I ENT = | 10440 | | | | | | | |
| SAN BERNARDINO | TOTAL = | 28800 | | | | | | | | | |
| | TOT ENT = | 28800 | M&I ENT = | 10800 | M GW ENT = | 18000 | | | | | |
| SAN GABRIEL | TOTAL = | 14000 | M GW ENT = | 14000 | | | | | | | |
| VENTURA CO FCD | TOTAL = | 5000 | M&I ENT = | 5000 | | | | | | | |
| SHELL CAL PROD. | TOTAL = | 1000 | REPAYMNT = | 1000 | | | | | | | |
| JG BOSWELL | TOTAL = | 8000 | REPAYMNT = | 8000 | | | | | | | |
| FISH & GAME | TOTAL = | 660 | REC/F&WL = | 660 | | | | | | | |

FILE DUMP

FILE IDENTIFICATION: P199090 12/15/89. SHEET 1

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT10 | FR | 50 | 50 | 120 | 70 | 70 | 90 | 170 | 200 | 170 | 90 | 60 | 60 | 1200 |
| *** TOTAL *** | | | 50 | 50 | 120 | 70 | 70 | 90 | 170 | 200 | 170 | 90 | 60 | 60 | 1200 |
| PLUMAS CO FCWCD | M&I ENT=WT10 | FR | 26 | 31 | 42 | 72 | 104 | 150 | 166 | 166 | 166 | 44 | 36 | 35 | 1038 |
| *** TOTAL *** | | | 26 | 31 | 42 | 72 | 104 | 150 | 166 | 166 | 166 | 44 | 36 | 35 | 1038 |
| YUBA CITY | M&I ENT=WT10 | FR | 0 | 0 | 0 | 0 | 0 | 100 | 600 | 600 | 400 | 100 | 0 | 0 | 1800 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 100 | 600 | 600 | 400 | 100 | 0 | 0 | 1800 |
| NAPA CO FCWCD | M&I ENT=WT10 | 3NB | 487 | 302 | 314 | 355 | 564 | 719 | 742 | 742 | 608 | 548 | 459 | 547 | 6387 |
| *** TOTAL *** | | | 487 | 302 | 314 | 355 | 564 | 719 | 742 | 742 | 608 | 548 | 459 | 547 | 6387 |
| SOLANO CO FCWCD | M&I ENT=WT10 | 1NB | 135 | 135 | 165 | 495 | 495 | 525 | 660 | 685 | 680 | 640 | 640 | 595 | 5850 |
| SOLANO CO FCWCD | VAL PMT =WT71 | 1NB | 0 | 0 | 0 | 20 | 110 | 205 | 235 | 235 | 120 | 55 | 20 | 0 | 1000 |
| SOLANO CO FCWCD | BEN ENT =WT46 | 3NA | 845 | 665 | 860 | 995 | 1070 | 975 | 1140 | 1125 | 1075 | 1045 | 965 | 840 | 11600 |
| SOLANO CO FCWCD | VAL ENT =WT47 | 3NA | 300 | 300 | 300 | 330 | 330 | 340 | 340 | 330 | 330 | 300 | 300 | 300 | 3800 |
| SOLANO CO FCWCD | VAL PMT =WT71 | 3NA | 500 | 500 | 500 | 600 | 900 | 950 | 1200 | 1100 | 800 | 600 | 300 | 300 | 8250 |
| *** TOTAL *** | | | 1780 | 1600 | 1825 | 2440 | 2905 | 2995 | 3575 | 3475 | 3005 | 2640 | 2225 | 2035 | 30500 |
| ZONE-7 ALAMEDA | M&I ENT=WT10 | 1SB | 3 | 2 | 2 | 8 | 21 | 30 | 34 | 36 | 29 | 20 | 7 | 3 | 195 |
| ZONE-7 ALAMEDA | M&I ENT=WT10 | 2SB | 514 | 479 | 540 | 679 | 988 | 1191 | 1297 | 1257 | 1088 | 873 | 595 | 518 | 10019 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 4SB | 188 | 188 | 188 | 188 | 188 | 188 | 192 | 192 | 188 | 188 | 188 | 188 | 2264 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 4SB | 1 | 1 | 82 | 219 | 382 | 399 | 409 | 370 | 11 | 107 | 1 | 1 | 1983 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 5SB | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 188 | 2256 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 5SB | 0 | 0 | 0 | 10 | 30 | 30 | 30 | 10 | 0 | 10 | 0 | 0 | 120 |
| ZONE-7 ALAMEDA | M&I ENT=WT10 | 6SB | 772 | 719 | 809 | 1019 | 1482 | 1786 | 1945 | 1886 | 1631 | 1310 | 892 | 777 | 15028 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 6SB | 0 | 0 | 0 | 15 | 20 | 35 | 35 | 25 | 5 | 0 | 0 | 0 | 135 |
| *** TOTAL *** | | | 1666 | 1577 | 1809 | 2326 | 3299 | 3847 | 4130 | 3964 | 3140 | 2696 | 1871 | 1675 | 32000 |
| ALAMEDA CO WD | M GW ENT=WT08 | 7SB | 1230 | 1390 | 1813 | 2700 | 2363 | 2533 | 2573 | 2573 | 2473 | 2437 | 2835 | 1230 | 26150 |
| ALAMEDA CO WD | A GW ENT=WT22 | 7SB | 0 | 0 | 0 | 0 | 100 | 200 | 200 | 200 | 200 | 150 | 0 | 0 | 1050 |
| ALAMEDA CO WD | WET WTHR=WT07 | 7SB | 0 | 0 | 0 | 200 | 845 | 602 | 535 | 535 | 662 | 721 | 500 | 500 | 5100 |
| ALAMEDA CO WD | M&I ENT=WT10 | 8SB | 824 | 744 | 824 | 797 | 824 | 797 | 824 | 824 | 797 | 824 | 797 | 824 | 9700 |
| *** TOTAL *** | | | 2054 | 2134 | 2637 | 3697 | 4132 | 4132 | 4132 | 4132 | 4132 | 4132 | 4132 | 2554 | 42000 |
| SANTA CLARA VWD | M&I ENT=WT10 | 9SB | 0 | 0 | 0 | 7000 | 9000 | 9300 | 9500 | 9500 | 9300 | 9000 | 4800 | 4800 | 72200 |
| SANTA CLARA VWD | M GW ENT=WT08 | 9SB | 0 | 0 | 0 | 3410 | 1760 | 1640 | 1810 | 1810 | 1640 | 1760 | 2970 | 3000 | 19800 |
| SANTA CLARA VWD | PURCHASD=WT76 | 9SB | 10360 | 9710 | 10760 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30830 |
| *** TOTAL *** | | | 10360 | 9710 | 10760 | 10410 | 10760 | 10940 | 11310 | 11310 | 10940 | 10760 | 7770 | 7800 | 122830 |
| DEVIL'S DEN WD | AGR ENT=WT01 | 31A | 254 | 381 | 762 | 1016 | 1270 | 2032 | 2286 | 2286 | 1143 | 508 | 381 | 381 | 12700 |
| DEVIL'S DEN WD | AGR SUR=WT04 | 31A | 1496 | 1349 | 1438 | 364 | 0 | 0 | 774 | 674 | 0 | 0 | 0 | 1205 | 7300 |
| *** TOTAL *** | | | 1750 | 1730 | 2200 | 1380 | 1270 | 2032 | 3060 | 2960 | 1143 | 508 | 381 | 1586 | 20000 |
| DUDLEY RIDGE WD | AGR ENT=WT01 | 8D | 0 | 0 | 3410 | 4290 | 6825 | 10730 | 12760 | 11105 | 3010 | 2630 | 1420 | 1520 | 57700 |
| DUDLEY RIDGE WD | CYOV ENT=WT69 | 8D | 3116 | 5691 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8807 |
| *** TOTAL *** | | | 3116 | 5691 | 3410 | 4290 | 6825 | 10730 | 12760 | 11105 | 3010 | 2630 | 1420 | 1520 | 66507 |

FILE IDENTIFICATION: P199090

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EMPIRE WS ID | AGR ENT=WT01 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | AGR SUR=WT04 | 8C | 390 | 160 | 320 | 60 | 0 | 320 | 460 | 460 | 330 | 80 | 260 | 160 | 3000 |
| EMPIRE WS ID | TRANSFER=WT67 | 8C | 775 | 1167 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1942 |
| *** TOTAL *** | | | 1225 | 1417 | 500 | 300 | 300 | 800 | 1000 | 1000 | 600 | 200 | 350 | 250 | 7942 |
| KERN COUNTY WA | AGR ENT=WT01 | 9 | 5100 | 8100 | 13600 | 12600 | 11600 | 18900 | 23900 | 22950 | 9600 | 6600 | 4300 | 3900 | 141150 |
| KERN COUNTY WA | CYOV ENT=WT69 | 9 | 6700 | 8800 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15500 |
| KERN COUNTY WA | M&I ENT=WT10 | 10A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 1200 |
| KERN COUNTY WA | M GW ENT=WT08 | 10A | 200 | 350 | 400 | 200 | 500 | 800 | 800 | 1000 | 800 | 0 | 0 | 0 | 5050 |
| KERN COUNTY WA | AGR ENT=WT01 | 10A | 855 | 2420 | 8467 | 20611 | 31752 | 52790 | 59807 | 55860 | 13364 | 5674 | 4974 | 4961 | 261535 |
| KERN COUNTY WA | CYOV ENT=WT69 | 10A | 5629 | 8096 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13725 |
| KERN COUNTY WA | AGR SUR=WT04 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M&I ENT=WT10 | 11B | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 15096 |
| KERN COUNTY WA | AGR ENT=WT01 | 11B | 2810 | 6864 | 6601 | 5764 | 7775 | 19773 | 35751 | 34864 | 4667 | 3017 | 2651 | 2773 | 133310 |
| KERN COUNTY WA | CYOV ENT=WT69 | 11B | 5616 | 5616 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11232 |
| KERN COUNTY WA | M&I ENT=WT10 | 12E | 2090 | 1970 | 2280 | 2470 | 2950 | 3180 | 3490 | 3440 | 2900 | 2590 | 1980 | 2090 | 31430 |
| KERN COUNTY WA | M GW ENT=WT08 | 12E | 3450 | 3750 | 1300 | 500 | 2400 | 9975 | 14335 | 12235 | 7125 | 5940 | 6120 | 11430 | 78560 |
| KERN COUNTY WA | AGR ENT=WT01 | 12E | 3764 | 5228 | 5238 | 7584 | 17424 | 25270 | 26120 | 20347 | 14892 | 1528 | 764 | 0 | 128159 |
| KERN COUNTY WA | CYOV ENT=WT69 | 12E | 3329 | 3795 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7124 |
| KERN COUNTY WA | AGR SUR=WT04 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | AGR ENT=WT01 | 13B | 250 | 1521 | 2675 | 2785 | 3298 | 8035 | 9635 | 7301 | 0 | 0 | 0 | 0 | 35500 |
| KERN COUNTY WA | AGR SUR=WT04 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M&I ENT=WT10 | 14A | 67 | 67 | 66 | 67 | 67 | 66 | 67 | 67 | 66 | 67 | 67 | 66 | 800 |
| KERN COUNTY WA | AGR ENT=WT01 | 14A | 0 | 0 | 6200 | 5800 | 5700 | 11200 | 12500 | 11700 | 3900 | 1600 | 1100 | 700 | 60400 |
| KERN COUNTY WA | CYOV ENT=WT69 | 14A | 1100 | 4000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5100 |
| KERN COUNTY WA | AGR ENT=WT01 | 14B | 0 | 0 | 4000 | 3000 | 4000 | 8000 | 8000 | 8000 | 2000 | 1000 | 1000 | 600 | 39600 |
| KERN COUNTY WA | CYOV ENT=WT69 | 14B | 1100 | 3000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4100 |
| KERN COUNTY WA | AGR ENT=WT01 | 14C | 0 | 0 | 4000 | 3000 | 4000 | 8000 | 8000 | 8000 | 2000 | 1000 | 1000 | 600 | 39600 |
| KERN COUNTY WA | CYOV ENT=WT69 | 14C | 1100 | 3000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4100 |
| KERN COUNTY WA | AGR ENT=WT01 | 15A | 0 | 0 | 4100 | 3400 | 6500 | 8200 | 9000 | 7300 | 3000 | 3300 | 2200 | 1600 | 48600 |
| KERN COUNTY WA | CYOV ENT=WT69 | 15A | 400 | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2400 |
| KERN COUNTY WA | M&I ENT=WT10 | 16A | 0 | 0 | 0 | 100 | 320 | 320 | 344 | 320 | 420 | 736 | 0 | 0 | 2560 |
| KERN COUNTY WA | AGR ENT=WT01 | 16A | 0 | 0 | 600 | 2400 | 2600 | 3500 | 3900 | 3200 | 2300 | 1700 | 1200 | 1500 | 22900 |
| KERN COUNTY WA | CYOV ENT=WT69 | 16A | 200 | 200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 400 |
| KERN COUNTY WA | AGR ENT=WT01 | 31A | 2650 | 4000 | 5900 | 10800 | 17600 | 17000 | 17000 | 15100 | 8000 | 5300 | 1500 | 3100 | 107950 |
| KERN COUNTY WA | AGR SUR=WT04 | 31A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 47768 | 74135 | 66785 | 82439 | 119844 | 196367 | 234007 | 213042 | 76392 | 41410 | 30214 | 34678 | 1217081 |
| COUNTY OF KINGS | M&I ENT=WT10 | 8C | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| *** TOTAL *** | | | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| OAK FLAT WD | AGR ENT=WT01 | 2A | 0 | 171 | 342 | 627 | 684 | 912 | 1026 | 1026 | 513 | 228 | 171 | 0 | 5700 |
| OAK FLAT WD | AGR SUR=WT04 | 2A | 0 | 64 | 208 | 500 | 600 | 304 | 324 | 0 | 0 | 0 | 0 | 0 | 2000 |
| *** TOTAL *** | | | 0 | 235 | 550 | 1127 | 1284 | 1216 | 1350 | 1026 | 513 | 228 | 171 | 0 | 7700 |
| TULARE LK BWSD | AGR ENT=WT01 | 8C | 920 | 1633 | 1938 | 3774 | 2536 | 7153 | 6771 | 6714 | 2083 | 2898 | 4993 | 5988 | 47401 |
| TULARE LK BWSD | PURCHASD=WT76 | 8C | 9725 | 6643 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16368 |
| TULARE LK BWSD | AGR ENT=WT01 | 8D | 1381 | 2449 | 2906 | 5662 | 3803 | 10729 | 10156 | 10070 | 3124 | 4347 | 7489 | 8983 | 71099 |
| TULARE LK BWSD | PURCHASD=WT76 | 8D | 13609 | 8325 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21934 |
| *** TOTAL *** | | | 25635 | 19050 | 4844 | 9436 | 6339 | 17882 | 16927 | 16784 | 5207 | 7245 | 12482 | 14971 | 156802 |

FILE IDENTIFICATION: P199090

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AVEK WA | M&I ENT=WT10 | 19 | 170 | 300 | 350 | 400 | 450 | 500 | 575 | 575 | 500 | 400 | 250 | 225 | 4695 |
| AVEK WA | AGR ENT=WT01 | 19 | 55 | 285 | 1885 | 2920 | 3080 | 3190 | 3600 | 3250 | 2180 | 1475 | 285 | 45 | 22250 |
| AVEK WA | M&I ENT=WT10 | 20A | 1275 | 950 | 1300 | 2000 | 2225 | 2500 | 3000 | 2825 | 2200 | 1800 | 1650 | 1275 | 23000 |
| AVEK WA | AGR ENT=WT01 | 20A | 2 | 3 | 5 | 15 | 20 | 25 | 35 | 35 | 30 | 15 | 3 | 2 | 190 |
| AVEK WA | M&I ENT=WT10 | 20B | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 60 |
| AVEK WA | M&I ENT=WT10 | 22A | 195 | 210 | 250 | 290 | 320 | 365 | 430 | 430 | 410 | 325 | 220 | 190 | 3635 |
| AVEK WA | AGR ENT=WT01 | 22A | 20 | 20 | 100 | 100 | 150 | 150 | 250 | 200 | 100 | 50 | 20 | 10 | 1170 |
| *** TOTAL *** | | | 1722 | 1773 | 3895 | 5730 | 6250 | 6735 | 7895 | 7320 | 5425 | 4070 | 2433 | 1752 | 55000 |
| CASTAIC LAKE WA | M&I ENT=WT10 | 30 | 1200 | 1350 | 1500 | 1900 | 2300 | 2300 | 2300 | 2300 | 2300 | 2100 | 1600 | 1400 | 22550 |
| *** TOTAL *** | | | 1200 | 1350 | 1500 | 1900 | 2300 | 2300 | 2300 | 2300 | 2300 | 2100 | 1600 | 1400 | 22550 |
| COACHELLA VALLY | M GW ENT=WT08 | 26A | 0 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 23100 |
| *** TOTAL *** | | | 0 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 2100 | 23100 |
| CRESTLINE-LA WA | M&I ENT=WT10 | 24 | 246 | 144 | 144 | 148 | 199 | 224 | 286 | 390 | 286 | 208 | 208 | 182 | 2665 |
| *** TOTAL *** | | | 246 | 144 | 144 | 148 | 199 | 224 | 286 | 390 | 286 | 208 | 208 | 182 | 2665 |
| DESERT WA | M&I ENT=WT10 | 26A | 0 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3460 | 38100 |
| *** TOTAL *** | | | 0 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3464 | 3460 | 38100 |
| LITTLEROCK CR | M&I ENT=WT10 | 21 | 0 | 0 | 131 | 150 | 187 | 225 | 262 | 244 | 225 | 161 | 131 | 0 | 1716 |
| LITTLEROCK CR | AGR ENT=WT01 | 21 | 0 | 0 | 44 | 50 | 63 | 75 | 88 | 81 | 75 | 64 | 44 | 0 | 584 |
| *** TOTAL *** | | | 0 | 0 | 175 | 200 | 250 | 300 | 350 | 325 | 300 | 225 | 175 | 0 | 2300 |
| METROPOLITAN WD | STOR ENT=WT60 | 12E | 15000 | 15000 | 15000 | 15000 | 0 | 0 | 0 | 0 | 15000 | 15000 | 15000 | 15000 | 120000 |
| METROPOLITAN WD | M&I ENT=WT10 | 26A | 0 | 4436 | 5736 | 7736 | 15236 | 8936 | 16936 | 16936 | 25036 | 16236 | 11736 | 3740 | 132700 |
| METROPOLITAN WD | M GW ENT=WT08 | 26A | 0 | 15000 | 15000 | 15000 | 9000 | 8000 | 3000 | 3000 | 3000 | 10000 | 10000 | 9000 | 100000 |
| METROPOLITAN WD | M&I ENT=WT10 | 28H | 0 | 4500 | 7000 | 8000 | 9000 | 10000 | 9000 | 9000 | 8000 | 6000 | 5000 | 4000 | 79500 |
| METROPOLITAN WD | BYPS ENT=WT59 | 28H | 0 | 10100 | 11300 | 13300 | 20800 | 14500 | 22500 | 22500 | 28000 | 21800 | 17300 | 9400 | 191500 |
| METROPOLITAN WD | M&I ENT=WT10 | 28J | 6900 | 400 | 400 | 400 | 400 | 13000 | 13000 | 13000 | 400 | 400 | 400 | 13300 | 62000 |
| METROPOLITAN WD | M&I ENT=WT10 | 30 | 55100 | 49000 | 56000 | 63000 | 72000 | 69000 | 72000 | 72000 | 69000 | 72000 | 63000 | 66000 | 778100 |
| *** TOTAL *** | | | 77000 | 98436 | 110436 | 122436 | 126436 | 123436 | 136436 | 136436 | 148436 | 141436 | 122436 | 120440 | 1463800 |
| MOJAVE WA | M&I ENT=WT10 | 22B | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 360 |
| *** TOTAL *** | | | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 360 |
| PALMDALE WD | M&I ENT=WT10 | 20A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| PALMDALE WD | M&I ENT=WT10 | 20B | 0 | 0 | 1160 | 1160 | 1160 | 1160 | 1160 | 1160 | 1160 | 1160 | 1160 | 0 | 10440 |
| *** TOTAL *** | | | 0 | 0 | 1160 | 1160 | 1160 | 1160 | 1160 | 1160 | 1160 | 1160 | 1160 | 0 | 10440 |
| SAN BERNARDINO | M&I ENT=WT10 | 26A | 0 | 0 | 0 | 0 | 1800 | 1800 | 1800 | 1800 | 1800 | 1800 | 0 | 0 | 10800 |
| SAN BERNARDINO | M GW ENT=WT08 | 26A | 0 | 0 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 0 | 18000 |
| *** TOTAL *** | | | 0 | 0 | 2000 | 2000 | 3800 | 3800 | 3800 | 3800 | 3800 | 3800 | 2000 | 0 | 28800 |
| SAN GABRIEL | M GW ENT=WT08 | 26A | 0 | 0 | 0 | 1750 | 1750 | 1750 | 1750 | 1750 | 1750 | 1750 | 1750 | 0 | 14000 |

STATE OF CALIFORNIA
THE RESOURCES AGENCY

FILE ID: 0199191

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1991

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

DATE: 11/05/90
PAGE: 1

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE TOTAL = | 1200 | | | | | | | |
| | | M&I ENT = | 1200 | | | | | |
| PLUMAS CO FCWCD TOTAL = | 1080 | | | | | | | |
| | | M&I ENT = | 1080 | | | | | |
| YUBA CITY TOTAL = | 2000 | | | | | | | |
| | | M&I ENT = | 2000 | | | | | |
| NAPA CO FCWCD TOTAL = | 6745 | | | | | | | |
| | | M&I ENT = | 6745 | | | | | |
| SOLANO CO WA TOTAL = | 32150 | | | | | | | |
| TOT ENT = | 22300 | M&I ENT = | 6500 | BEN ENT = | 12000 | VAL ENT = | 3800 | |
| TOT MISC = | 9850 | VAL PMT = | 9850 | | | | | |
| ZONE-7 ALAMEDA TOTAL = | 34000 | | | | | | | |
| TOT ENT = | 34000 | M&I ENT = | 26825 | M GW ENT = | 4693 | AGR ENT = | 2482 | |
| ALAMEDA CO WD TOTAL = | 42000 | | | | | | | |
| TOT ENT = | 38400 | M&I ENT = | 9700 | M GW ENT = | 28150 | A GW ENT = | 550 | |
| TOT MISC = | 3600 | WET WTHR = | 3600 | | | | | |
| SANTA CLARA VWD TOTAL = | 122907 | | | | | | | |
| TOT ENT = | 94000 | M&I ENT = | 72200 | M GW ENT = | 21800 | | | |
| TOT MISC = | 28907 | PURCHASD = | 28907 | | | | | |
| SANTA BARBARA TOTAL = | 3600 | | | | | | | |
| | | M&I ENT = | 3600 | | | | | |
| DEVIL'S DEN WD TOTAL = | 20000 | | | | | | | |
| | | AGR ENT = | 12700 | | | | | |
| | | AGR SUR = | 7300 | | | | | |
| DUDLEY RIDGE WD TOTAL = | 58128 | | | | | | | |
| | | AGR ENT = | 57700 | | | | | |
| | | CYOV ENT = | 428 | | | | | |
| EMPIRE WS ID TOTAL = | 6221 | | | | | | | |
| | | AGR ENT = | 3000 | | | | | |
| | | AGR SUR = | 3000 | | | | | |
| | | CYOV ENT = | 221 | | | | | |
| KERN COUNTY WA TOTAL = | 1324663 | | | | | | | |
| TOT ENT = | 1153400 | M&I ENT = | 52210 | M GW ENT = | 82390 | AGR ENT = | 1018800 | |
| TOT MISC = | 171263 | 12D AGR = | 100000 | 78MWD 30 = | 21547 | X82 ORO = | 46393 | X82 MWD = 3323 |
| COUNTY OF KINGS TOTAL = | 6000 | | | | | | | |
| | | AGR ENT = | 4000 | | | | | |
| | | 12D AGR = | 2000 | | | | | |

199

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OAK FLAT WD | TOTAL = | 7200 | AGR | ENT = | 5700 | | | | | | |
| | | | AGR | SUR = | 1500 | | | | | | |
| TULARE LK BWSD | TOTAL = | 264712 | AGR | ENT = | 118500 | | | | | | |
| | TOT MISC = | 146212 | 12D | AGR = | 59250 | WET WTHR = | 80662 | CYOV ENT = | 6300 | | |
| AVEK WA | TOTAL = | 63492 | | | | | | | | | |
| | TOT ENT = | 63492 | M&I | ENT = | 45984 | AGR ENT = | 17508 | | | | |
| CASTAIC LAKE WA | TOTAL = | 26100 | M&I | ENT = | 26100 | | | | | | |
| COACHELLA VALLY | TOTAL = | 23100 | M&I | ENT = | 23100 | | | | | | |
| CRESTLINE-LA WA | TOTAL = | 2420 | M&I | ENT = | 2420 | | | | | | |
| DESERT WA | TOTAL = | 38100 | M GW | ENT = | 38100 | | | | | | |
| LITTLEROCK CR | TOTAL = | 2300 | | | | | | | | | |
| | TOT ENT = | 2300 | M&I | ENT = | 1716 | AGR ENT = | 584 | | | | |
| METROPOLITAN WD | TOTAL = | 1774000 | | | | | | | | | |
| | TOT ENT = | 1749130 | M&I | ENT = | 1245030 | M GW ENT = | 70000 | BYPS ENT = | 314100 | SWP STOR = | 120000 |
| | TOT MISC = | 24870 | 78 EX GW | = | 21547 | X82 GW = | 3323 | | | | |
| MOJAVE WA | TOTAL = | 50800 | M GW | ENT = | 50800 | | | | | | |
| PALMDALE WD | TOTAL = | 13050 | M&I | ENT = | 13050 | | | | | | |
| SAN BERNARDINO | TOTAL = | 30000 | | | | | | | | | |
| | TOT ENT = | 30000 | M&I | ENT = | 10000 | M GW ENT = | 20000 | | | | |
| SAN GABRIEL | TOTAL = | 18000 | M GW | ENT = | 18000 | | | | | | |
| VENTURA CO FCD | TOTAL = | 6180 | M&I | ENT = | 5000 | | | | | | |
| | | | CYOVMENT | = | 1180 | | | | | | |
| THERMALITO ID | TOTAL = | 8200 | LOCAL | = | 8200 | | | | | | |

FILE DUMP

FILE IDENTIFICATION: 0199191 11/05/90. SHEET 1

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT10 | FR | 50 | 50 | 120 | 70 | 70 | 90 | 170 | 200 | 170 | 90 | 60 | 60 | 1200 |
| *** TOTAL *** | | | 50 | 50 | 120 | 70 | 70 | 90 | 170 | 200 | 170 | 90 | 60 | 60 | 1200 |
| PLUMAS CO FCWCD | M&I ENT=WT10 | FR | 27 | 32 | 43 | 79 | 109 | 156 | 173 | 173 | 173 | 42 | 37 | 36 | 1080 |
| *** TOTAL *** | | | 27 | 32 | 43 | 79 | 109 | 156 | 173 | 173 | 173 | 42 | 37 | 36 | 1080 |
| YUBA CITY | M&I ENT=WT10 | FR | 0 | 0 | 0 | 0 | 0 | 200 | 600 | 700 | 400 | 100 | 0 | 0 | 2000 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 200 | 600 | 700 | 400 | 100 | 0 | 0 | 2000 |
| NAPA CO FCWCD | M&I ENT=WT10 | 3NB | 539 | 335 | 371 | 511 | 609 | 684 | 715 | 651 | 618 | 578 | 550 | 584 | 6745 |
| *** TOTAL *** | | | 539 | 335 | 371 | 511 | 609 | 684 | 715 | 651 | 618 | 578 | 550 | 584 | 6745 |
| SOLANO CO WA | M&I ENT=WT10 | 1NB | 335 | 385 | 385 | 590 | 670 | 695 | 700 | 695 | 695 | 560 | 405 | 385 | 6500 |
| SOLANO CO WA | VAL PMT =WT71 | 1NB | 0 | 0 | 0 | 20 | 110 | 205 | 235 | 235 | 120 | 55 | 20 | 0 | 1000 |
| SOLANO CO WA | BEN ENT =WT46 | 3NA | 875 | 690 | 885 | 1030 | 1110 | 1010 | 1180 | 1165 | 1110 | 1080 | 1000 | 865 | 12000 |
| SOLANO CO WA | VAL ENT =WT47 | 3NA | 300 | 300 | 300 | 330 | 330 | 340 | 340 | 330 | 330 | 300 | 300 | 300 | 3800 |
| SOLANO CO WA | VAL PMT =WT71 | 3NA | 550 | 550 | 550 | 650 | 950 | 1000 | 1250 | 1150 | 850 | 650 | 350 | 350 | 8850 |
| *** TOTAL *** | | | 2060 | 1925 | 2120 | 2620 | 3170 | 3250 | 3705 | 3575 | 3105 | 2645 | 2075 | 1900 | 32150 |
| ZONE-7 ALAMEDA | M&I ENT=WT10 | 1SB | 2 | 2 | 3 | 11 | 23 | 31 | 34 | 37 | 31 | 21 | 6 | 2 | 203 |
| ZONE-7 ALAMEDA | M&I ENT=WT10 | 2SB | 372 | 347 | 448 | 599 | 763 | 849 | 921 | 914 | 791 | 639 | 431 | 379 | 7453 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 4SB | 196 | 196 | 196 | 196 | 196 | 196 | 196 | 196 | 196 | 196 | 196 | 196 | 2352 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 4SB | 0 | 0 | 83 | 218 | 432 | 449 | 460 | 424 | 13 | 108 | 0 | 0 | 2187 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 5SB | 195 | 195 | 195 | 195 | 195 | 195 | 195 | 196 | 195 | 195 | 195 | 195 | 2341 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 5SB | 0 | 0 | 0 | 10 | 40 | 40 | 40 | 20 | 0 | 10 | 0 | 0 | 160 |
| ZONE-7 ALAMEDA | M&I ENT=WT10 | 6SB | 956 | 894 | 1151 | 1542 | 1962 | 2182 | 2369 | 2351 | 2034 | 1643 | 1109 | 976 | 19169 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 6SB | 0 | 0 | 0 | 15 | 20 | 35 | 35 | 25 | 5 | 0 | 0 | 0 | 135 |
| *** TOTAL *** | | | 1721 | 1634 | 2076 | 2786 | 3631 | 3977 | 4250 | 4163 | 3265 | 2812 | 1937 | 1748 | 34000 |
| ALAMEDA CO WD | M GW ENT=WT08 | 7SB | 1230 | 1110 | 1530 | 2670 | 2970 | 3170 | 3280 | 3280 | 2870 | 2710 | 2080 | 1250 | 28150 |
| ALAMEDA CO WD | A GW ENT=WT22 | 7SB | 0 | 0 | 0 | 0 | 100 | 100 | 100 | 100 | 100 | 50 | 0 | 0 | 550 |
| ALAMEDA CO WD | WET WTHR=WT07 | 7SB | 0 | 0 | 0 | 200 | 300 | 500 | 500 | 500 | 400 | 400 | 400 | 400 | 3600 |
| ALAMEDA CO WD | M&I ENT=WT10 | 8SB | 824 | 744 | 824 | 797 | 824 | 797 | 824 | 824 | 797 | 824 | 797 | 824 | 9700 |
| *** TOTAL *** | | | 2054 | 1854 | 2354 | 3667 | 4194 | 4567 | 4704 | 4704 | 4167 | 3984 | 3277 | 2474 | 42000 |
| SANTA CLARA VWD | M&I ENT=WT10 | 9SB | 0 | 0 | 0 | 7000 | 9000 | 9300 | 9500 | 9500 | 9300 | 9000 | 4800 | 4800 | 72200 |
| SANTA CLARA VWD | M GW ENT=WT08 | 9SB | 0 | 0 | 0 | 3410 | 1760 | 1640 | 1810 | 1810 | 1640 | 1760 | 3970 | 4000 | 21800 |
| SANTA CLARA VWD | PURCHASD=WT76 | 9SB | 9950 | 9000 | 9957 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28907 |
| *** TOTAL *** | | | 9950 | 9000 | 9957 | 10410 | 10760 | 10940 | 11310 | 11310 | 10940 | 10760 | 8770 | 8800 | 122907 |
| SANTA BARBARA | M&I ENT=WT10 | 30 | 383 | 346 | 383 | 370 | 383 | 279 | 95 | 95 | 130 | 383 | 370 | 383 | 3600 |
| *** TOTAL *** | | | 383 | 346 | 383 | 370 | 383 | 279 | 95 | 95 | 130 | 383 | 370 | 383 | 3600 |
| DEVIL'S DEN WD | AGR ENT=WT01 | 31A | 254 | 381 | 762 | 1016 | 1270 | 2032 | 2286 | 2286 | 1143 | 508 | 381 | 381 | 12700 |
| DEVIL'S DEN WD | AGR SUR=WT04 | 31A | 1496 | 1349 | 1438 | 364 | 0 | 0 | 774 | 674 | 0 | 0 | 0 | 1205 | 7300 |
| *** TOTAL *** | | | 1750 | 1730 | 2200 | 1380 | 1270 | 2032 | 3060 | 2960 | 1143 | 508 | 381 | 1586 | 20000 |

FILE DUMP

FILE IDENTIFICATION: 0199191 11/05/90. SHEET 2

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUDLEY RIDGE WD | AGR ENT=WT01 | 8D | 2567 | 6411 | 2970 | 3503 | 6041 | 10152 | 10082 | 9551 | 2098 | 1957 | 1127 | 1241 | 57700 |
| DUDLEY RIDGE WD | CYOV ENT=WT69 | 8D | 428 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 428 |
| *** TOTAL *** | | | 2995 | 6411 | 2970 | 3503 | 6041 | 10152 | 10082 | 9551 | 2098 | 1957 | 1127 | 1241 | 58128 |
| EMPIRE WS ID | AGR ENT=WT01 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | CYOV ENT=WT69 | 8C | 100 | 121 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 221 |
| EMPIRE WS ID | AGR SUR=WT04 | 8C | 390 | 160 | 320 | 60 | 0 | 460 | 460 | 320 | 330 | 80 | 260 | 160 | 3000 |
| *** TOTAL *** | | | 550 | 371 | 500 | 300 | 300 | 940 | 1000 | 860 | 600 | 200 | 350 | 250 | 6221 |
| KERN COUNTY WA | AGR ENT=WT01 | 9 | 3550 | 6390 | 7100 | 8520 | 8410 | 17300 | 24880 | 17750 | 4260 | 2840 | 710 | 5822 | 107532 |
| KERN COUNTY WA | M&I ENT=WT10 | 10A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 1200 |
| KERN COUNTY WA | M GW ENT=WT08 | 10A | 0 | 150 | 300 | 0 | 300 | 800 | 800 | 1200 | 900 | 0 | 0 | 0 | 4450 |
| KERN COUNTY WA | AGR ENT=WT01 | 10A | 3805 | 20530 | 16799 | 16417 | 28268 | 45916 | 54253 | 50436 | 8430 | 1160 | 290 | 2564 | 248868 |
| KERN COUNTY WA | 12D AGR=WT13 | 10A | 0 | 0 | 136 | 0 | 0 | 0 | 0 | 0 | 1000 | 1000 | 1652 | 2000 | 5788 |
| KERN COUNTY WA | X82 ORO=WT51 | 10A | 0 | 0 | 5758 | 6000 | 0 | 0 | 0 | 0 | 5000 | 5000 | 1348 | 1000 | 24106 |
| KERN COUNTY WA | M&I ENT=WT10 | 11B | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1162 | 15000 |
| KERN COUNTY WA | AGR ENT=WT01 | 11B | 2810 | 6864 | 6601 | 5764 | 7775 | 19773 | 35751 | 34864 | 4667 | 3017 | 2651 | 2869 | 133406 |
| KERN COUNTY WA | M&I ENT=WT10 | 12E | 2110 | 1990 | 2300 | 2490 | 3010 | 3220 | 3500 | 3450 | 2920 | 2610 | 2000 | 2110 | 31710 |
| KERN COUNTY WA | M GW ENT=WT08 | 12E | 450 | 750 | 1300 | 500 | 5030 | 13815 | 14355 | 17245 | 5825 | 5940 | 6320 | 6410 | 77940 |
| KERN COUNTY WA | AGR ENT=WT01 | 12E | 2990 | 10761 | 7900 | 12076 | 20200 | 27500 | 26050 | 25452 | 13200 | 0 | 0 | 0 | 146129 |
| KERN COUNTY WA | 12D AGR=WT13 | 12E | 0 | 2729 | 7833 | 10000 | 2100 | 6100 | 6100 | 7702 | 10100 | 13640 | 13640 | 13640 | 93584 |
| KERN COUNTY WA | 78MWD 30=WT16 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2047 | 6500 | 6500 | 6500 | 21547 |
| KERN COUNTY WA | X82 ORO=WT51 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1239 | 5000 | 5000 | 5000 | 16239 |
| KERN COUNTY WA | X82 MWD=WT52 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 323 | 1000 | 1000 | 1000 | 3323 |
| KERN COUNTY WA | AGR ENT=WT01 | 13B | 300 | 1575 | 2907 | 3001 | 3585 | 11000 | 11000 | 5593 | 400 | 800 | 800 | 3324 | 44285 |
| KERN COUNTY WA | 12D AGR=WT13 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 628 | 628 |
| KERN COUNTY WA | X82 ORO=WT51 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6048 | 6048 |
| KERN COUNTY WA | M&I ENT=WT10 | 14A | 67 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 63 | 820 |
| KERN COUNTY WA | AGR ENT=WT01 | 14A | 392 | 2747 | 3139 | 1766 | 2747 | 5494 | 6475 | 5101 | 1177 | 785 | 392 | 3015 | 33230 |
| KERN COUNTY WA | M&I ENT=WT10 | 14B | 0 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 0 | 60 |
| KERN COUNTY WA | AGR ENT=WT01 | 14B | 1101 | 7708 | 8809 | 4955 | 7708 | 15417 | 18170 | 14315 | 3304 | 2202 | 1101 | 8463 | 93253 |
| KERN COUNTY WA | M&I ENT=WT10 | 14C | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 20 |
| KERN COUNTY WA | AGR ENT=WT01 | 14C | 506 | 3545 | 4051 | 2279 | 3545 | 7090 | 8356 | 6583 | 1519 | 1013 | 506 | 3895 | 42888 |
| KERN COUNTY WA | M&I ENT=WT10 | 15A | 0 | 0 | 10 | 0 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 50 |
| KERN COUNTY WA | AGR ENT=WT01 | 15A | 1000 | 1000 | 4000 | 2000 | 6000 | 8000 | 8000 | 5000 | 3000 | 3000 | 2000 | 6943 | 49943 |
| KERN COUNTY WA | M&I ENT=WT10 | 16A | 0 | 0 | 10 | 360 | 1002 | 970 | 998 | 10 | 0 | 0 | 0 | 0 | 3350 |
| KERN COUNTY WA | AGR ENT=WT01 | 16A | 100 | 100 | 600 | 600 | 1200 | 1300 | 1704 | 1992 | 1460 | 1244 | 580 | 986 | 11866 |
| KERN COUNTY WA | AGR ENT=WT01 | 31A | 2700 | 4000 | 5900 | 10800 | 17000 | 17000 | 17000 | 15100 | 8000 | 5300 | 1500 | 3100 | 107400 |
| *** TOTAL *** | | | 23239 | 72274 | 86888 | 88963 | 119325 | 202140 | 238837 | 213238 | 80206 | 63486 | 49425 | 86642 | 1324663 |
| COUNTY OF KINGS | AGR ENT=WT01 | 8C | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| COUNTY OF KINGS | 12D AGR=WT13 | 8C | 100 | 130 | 110 | 90 | 140 | 340 | 370 | 280 | 80 | 60 | 140 | 160 | 2000 |
| *** TOTAL *** | | | 500 | 530 | 510 | 490 | 140 | 740 | 770 | 680 | 480 | 460 | 140 | 560 | 6000 |
| OAK FLAT WD | AGR ENT=WT01 | 2A | 64 | 171 | 342 | 456 | 627 | 1026 | 1026 | 1026 | 513 | 228 | 171 | 50 | 5700 |
| OAK FLAT WD | AGR SUR=WT04 | 2A | 0 | 0 | 108 | 273 | 423 | 238 | 324 | 134 | 0 | 0 | 0 | 0 | 1500 |
| *** TOTAL *** | | | 64 | 171 | 450 | 729 | 1050 | 1264 | 1350 | 1160 | 513 | 228 | 171 | 50 | 7200 |
| TULARE LK BWSD | AGR ENT=WT01 | 8C | 1892 | 1121 | 578 | 873 | 2652 | 9731 | 11165 | 7706 | 1058 | 740 | 3868 | 6015 | 47399 |
| TULARE LK BWSD | 12D AGR=WT13 | 8C | 1210 | 1540 | 1320 | 1100 | 1640 | 4060 | 4390 | 3290 | 990 | 770 | 1640 | 1760 | 23710 |
| TULARE LK BWSD | WET WTHR=WT07 | 8C | 1640 | 2090 | 1790 | 1490 | 2240 | 5530 | 5980 | 4480 | 1340 | 1040 | 2240 | 2402 | 32262 |

FILE DUMP

FILE IDENTIFICATION: 0199191 11/05/90. SHEET 3

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TULARE LK BWSD | CYOV ENT=WT69 | 8C | 1700 | 800 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2500 |
| TULARE LK BWSD | AGR ENT=WT01 | 8D | 2839 | 1682 | 868 | 1309 | 3978 | 14597 | 16748 | 11560 | 1588 | 1109 | 5801 | 9022 | 71101 |
| TULARE LK BWSD | 12D AGR=WT13 | 8D | 1810 | 2300 | 1970 | 1640 | 2470 | 6090 | 6580 | 4940 | 1480 | 1150 | 2470 | 2640 | 35540 |
| TULARE LK BWSD | WET WTHR=WT07 | 8D | 2470 | 3140 | 2690 | 2240 | 3360 | 8290 | 8960 | 6720 | 2020 | 1570 | 3360 | 3580 | 48400 |
| TULARE LK BWSD | CYOV ENT=WT69 | 8D | 2600 | 1200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3800 |
| *** TOTAL *** | | | 16161 | 13873 | 9216 | 8652 | 16340 | 48298 | 53823 | 38696 | 8476 | 6379 | 19379 | 25419 | 264712 |
| AVEK WA | M&I ENT=WT10 | 18A | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 39 |
| AVEK WA | M&I ENT=WT10 | 19 | 410 | 500 | 610 | 765 | 840 | 1025 | 1125 | 1090 | 870 | 680 | 490 | 470 | 8875 |
| AVEK WA | AGR ENT=WT01 | 19 | 26 | 395 | 1483 | 1887 | 2145 | 2507 | 2397 | 2390 | 1870 | 860 | 141 | 127 | 16228 |
| AVEK WA | M&I ENT=WT10 | 20A | 1435 | 1375 | 1765 | 2565 | 3275 | 3620 | 4305 | 3850 | 3295 | 2875 | 2340 | 1885 | 32585 |
| AVEK WA | AGR ENT=WT01 | 20A | 10 | 10 | 15 | 15 | 20 | 20 | 20 | 15 | 15 | 10 | 10 | 10 | 170 |
| AVEK WA | M&I ENT=WT10 | 20B | 70 | 65 | 120 | 105 | 150 | 150 | 160 | 170 | 140 | 140 | 115 | 110 | 1495 |
| AVEK WA | M&I ENT=WT10 | 22A | 145 | 155 | 205 | 245 | 305 | 325 | 365 | 365 | 325 | 245 | 165 | 145 | 2990 |
| AVEK WA | AGR ENT=WT01 | 22A | 10 | 20 | 80 | 100 | 125 | 140 | 250 | 220 | 100 | 50 | 10 | 5 | 1110 |
| *** TOTAL *** | | | 2107 | 2521 | 4279 | 5683 | 6861 | 7788 | 8625 | 8104 | 6620 | 4866 | 3278 | 2760 | 63492 |
| CASTAIC LAKE WA | M&I ENT=WT10 | 30 | 1450 | 1200 | 1750 | 1800 | 2300 | 2750 | 3000 | 3000 | 3000 | 2400 | 1850 | 1600 | 26100 |
| *** TOTAL *** | | | 1450 | 1200 | 1750 | 1800 | 2300 | 2750 | 3000 | 3000 | 3000 | 2400 | 1850 | 1600 | 26100 |
| COACHELLA VALLY | M&I ENT=WT10 | 26A | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| *** TOTAL *** | | | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| CRESTLINE-LA WA | M&I ENT=WT10 | 24 | 224 | 131 | 131 | 135 | 180 | 203 | 260 | 355 | 260 | 188 | 188 | 165 | 2420 |
| *** TOTAL *** | | | 224 | 131 | 131 | 135 | 180 | 203 | 260 | 355 | 260 | 188 | 188 | 165 | 2420 |
| DESERT WA | M GW ENT=WT08 | 26A | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| *** TOTAL *** | | | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| LITTLEROCK CR | M&I ENT=WT10 | 21 | 0 | 0 | 131 | 150 | 187 | 225 | 262 | 244 | 225 | 161 | 131 | 0 | 1716 |
| LITTLEROCK CR | AGR ENT=WT01 | 21 | 0 | 0 | 44 | 50 | 63 | 75 | 88 | 81 | 75 | 64 | 44 | 0 | 584 |
| *** TOTAL *** | | | 0 | 0 | 175 | 200 | 250 | 300 | 350 | 325 | 300 | 225 | 175 | 0 | 2300 |
| METROPOLITAN WD | SWP STOR=WT60 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30000 | 30000 | 30000 | 30000 | 120000 |
| METROPOLITAN WD | M&I ENT=WT10 | 26A | 20700 | 17900 | 21400 | 22900 | 32900 | 29500 | 29500 | 29500 | 30530 | 15400 | 15400 | 15000 | 280630 |
| METROPOLITAN WD | M GW ENT=WT08 | 26A | 10000 | 10000 | 10000 | 10000 | 0 | 0 | 0 | 0 | 0 | 10000 | 10000 | 10000 | 70000 |
| METROPOLITAN WD | 78 EX GW=WT37 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2047 | 6500 | 6500 | 6500 | 21547 |
| METROPOLITAN WD | X82 GW=WT54 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 323 | 1000 | 1000 | 1000 | 3323 |
| METROPOLITAN WD | M&I ENT=WT10 | 28H | 5000 | 5000 | 7000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 9000 | 7000 | 6000 | 99000 |
| METROPOLITAN WD | BYPS ENT=WT59 | 28H | 25900 | 23000 | 26500 | 26000 | 26000 | 26000 | 26000 | 26000 | 26000 | 27000 | 28000 | 27700 | 314100 |
| METROPOLITAN WD | M&I ENT=WT10 | 28J | 3800 | 3400 | 6600 | 2400 | 1400 | 9400 | 9400 | 9400 | 2400 | 2400 | 1400 | 400 | 52400 |
| METROPOLITAN WD | M&I ENT=WT10 | 30 | 72000 | 29000 | 72000 | 70000 | 72000 | 70000 | 72000 | 72000 | 70000 | 72000 | 70000 | 72000 | 813000 |
| *** TOTAL *** | | | 137400 | 88300 | 143500 | 141300 | 142300 | 144900 | 146900 | 146900 | 171300 | 173300 | 169300 | 168600 | 1774000 |
| MOJAVE WA | M GW ENT=WT08 | 24 | 5580 | 5580 | 5580 | 5580 | 5580 | 5580 | 0 | 0 | 5580 | 5580 | 5580 | 580 | 50800 |
| *** TOTAL *** | | | 5580 | 5580 | 5580 | 5580 | 5580 | 5580 | 0 | 0 | 5580 | 5580 | 5580 | 580 | 50800 |

STATE OF CALIFORNIA
THE RESOURCES AGENCY

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1992

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

FILE ID: N199292

DATE: 03/30/92
PAGE: 1

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE TOTAL = | 1085 | M^I ENT = | 1085 | | | | | | | | | | |
| PLUMAS CO FCWCD TOTAL = | 1120 | M^I ENT = | 1120 | | | | | | | | | | |
| YUBA CITY TOTAL = | 2200 | M^I ENT = | 2200 | | | | | | | | | | |
| NAPA CO FCWCD TOTAL = | 7840 | M^I ENT = | 7840 | | | | | | | | | | |
| SOLANO CO WA TOTAL = | 41457 | | | | | | | | | | | | |
| TOT ENT = | 24170 | M^I ENT = | 7720 | BEN ENT = | 12320 | VAL ENT = | 4130 | | | | | | |
| TOT MISC = | 17287 | VAL PMT = | 17287 | | | | | | | | | | |
| ZONE-7 ALAMEDA TOTAL = | 45970 | | | | | | | | | | | | |
| TOT ENT = | 45970 | M^I ENT = | 26065 | M GW ENT = | 6949 | AGR ENT = | 2956 | WETMWTHR = | 10000 | | | | |
| ALAMEDA CO WD TOTAL = | 42000 | | | | | | | | | | | | |
| TOT ENT = | 42000 | M^I ENT = | 9700 | M GW ENT = | 30200 | WETAWTHR = | 2100 | | | | | | |
| SANTA CLARA VWD TOTAL = | 96000 | | | | | | | | | | | | |
| TOT ENT = | 96000 | M^I ENT = | 84400 | M GW ENT = | 11600 | | | | | | | | |
| DEVIL'S DEN WD TOTAL = | 7300 | | | | | | | | | | | | |
| | | 12D AGR = | 3810 | | | | | | | | | | |
| | | AGR SUR = | 3490 | | | | | | | | | | |
| DUDLEY RIDGE WD TOTAL = | 59200 | | | | | | | | | | | | |
| | | AGR ENT = | 57700 | | | | | | | | | | |
| | | 91DRBANK = | 1500 | | | | | | | | | | |
| EMPIRE WS ID TOTAL = | 6000 | | | | | | | | | | | | |
| TOT ENT = | 6000 | AGR ENT = | 3000 | 12D AGR = | 3000 | | | | | | | | |
| KERN COUNTY WA TOTAL = | 1324663 | | | | | | | | | | | | |
| TOT ENT = | 1253400 | M^I ENT = | 52210 | M GW ENT = | 82390 | AGR ENT = | 1018800 | 12D AGR = | 100000 | | | | |
| TOT MISC = | 71263 | 78MWD 30 = | 21547 | X82 DRD = | 46393 | X82 MWD = | 3323 | | | | | | |
| COUNTY OF KINGS TOTAL = | 8000 | | | | | | | | | | | | |
| TOT ENT = | 8000 | AGR ENT = | 4000 | 12D AGR = | 4000 | | | | | | | | |
| OAK FLAT WD TOTAL = | 7200 | | | | | | | | | | | | |
| TOT ENT = | 7200 | AGR ENT = | 5700 | 12D AGR = | 1500 | | | | | | | | |
| TULARE LK BWSD TOTAL = | 258412 | | | | | | | | | | | | |
| TOT ENT = | 258412 | AGR ENT = | 118500 | 12D AGR = | 59250 | WETAWTHR = | 80662 | | | | | | |

STATE OF CALIFORNIA
THE RESOURCES AGENCY

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1992

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

FILE ID: N199292



| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| AVEK WA | TOTAL = | 65779 | | | | | | |
| | TOT ENT = | 65779 | M^I ENT = | 50459 | AGR ENT = | 15320 | | |
| CASTAIC LAKE WA | TOTAL = | 39504 | | | | | | |
| | TOT ENT = | 39504 | M^I ENT = | 26804 | AGR ENT = | 12700 | | |
| COACHELLA VALLY | TOTAL = | 23100 | | | | | | |
| | | | M^I ENT = | 23100 | | | | |
| CRESTLINE-LA WA | TOTAL = | 2050 | | | | | | |
| | | | M^I ENT = | 2050 | | | | |
| DESERT WA | TOTAL = | 38100 | | | | | | |
| | | | M GW ENT = | 38100 | | | | |
| LITTLEROCK CR | TOTAL = | 2300 | | | | | | |
| | TOT ENT = | 2300 | M^I ENT = | 1930 | AGR ENT = | 370 | | |
| METROPOLITAN WD | TOTAL = | 1937000 | | | | | | |
| | TOT ENT = | 1937000 | M^I ENT = | 1331331 | M GW ENT = | 213669 | BYPS ENT = 272000 | STOR ENT = 120000 |
| MOJAVE WA | TOTAL = | 24000 | | | | | | |
| | | | M GW ENT = | 24000 | | | | |
| PALMDALE WD | TOTAL = | 13200 | | | | | | |
| | | | M^I ENT = | 13200 | | | | |
| SAN BERNARDINO | TOTAL = | 32000 | | | | | | |
| | TOT ENT = | 32000 | M^I ENT = | 12000 | M GW ENT = | 20000 | | |
| SAN GABRIEL | TOTAL = | 18000 | | | | | | |
| | | | M GW ENT = | 18000 | | | | |
| VENTURA CO FCD | TOTAL = | 5000 | | | | | | |
| | | | M GW ENT = | 5000 | | | | |
| SHELL CAL PROD. | TOTAL = | 7362 | | | | | | |
| | | | REPAYMNT = | 7362 | | | | |
| JG BOSWELL | TOTAL = | 9000 | | | | | | |
| | | | REPAYMNT = | 9000 | | | | |
| FISH ^ GAME | TOTAL = | 660 | | | | | | |
| | | | REC/F^WL = | 660 | | | | |
| PARKS ^ RECREAT | TOTAL = | 90 | | | | | | |
| | | | REC/F^WL = | 90 | | | | |

FILE DUMP

FILE IDENTIFICATION: N199292 03/30/92. SHEET 1

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M^I ENT=WT10 | FR | 65 | 55 | 505 | 205 | 55 | 50 | 10 | 10 | 10 | 10 | 25 | 85 | 1085 |
| *** TOTAL *** | | | 65 | 55 | 505 | 205 | 55 | 50 | 10 | 10 | 10 | 10 | 25 | 85 | 1085 |
| PLUMAS CO FCWCD | M^I ENT=WT10 | FR | 28 | 33 | 44 | 81 | 114 | 162 | 180 | 180 | 180 | 43 | 38 | 37 | 1120 |
| *** TOTAL *** | | | 28 | 33 | 44 | 81 | 114 | 162 | 180 | 180 | 180 | 43 | 38 | 37 | 1120 |
| YUBA CITY | M^I ENT=WT10 | FR | 0 | 0 | 0 | 0 | 0 | 200 | 700 | 700 | 400 | 200 | 0 | 0 | 2200 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 200 | 700 | 700 | 400 | 200 | 0 | 0 | 2200 |
| NAPA CO FCWCD | M^I ENT=WT10 | 3NB | 562 | 358 | 409 | 603 | 737 | 796 | 798 | 798 | 772 | 730 | 633 | 644 | 7840 |
| *** TOTAL *** | | | 562 | 358 | 409 | 603 | 737 | 796 | 798 | 798 | 772 | 730 | 633 | 644 | 7840 |
| SOLANO CO WA | M^I ENT=WT10 | 1NB | 405 | 455 | 455 | 740 | 835 | 870 | 715 | 710 | 870 | 750 | 485 | 430 | 7720 |
| SOLANO CO WA | VAL PMT =WT71 | 1NB | 0 | 0 | 0 | 40 | 240 | 255 | 500 | 500 | 350 | 255 | 220 | 0 | 2360 |
| SOLANO CO WA | BEN ENT =WT46 | 3NA | 895 | 705 | 910 | 1055 | 1140 | 1040 | 1210 | 1195 | 1140 | 1110 | 1030 | 890 | 12320 |
| SOLANO CO WA | VAL ENT =WT47 | 3NA | 300 | 300 | 300 | 500 | 500 | 565 | 100 | 100 | 565 | 300 | 300 | 300 | 4130 |
| SOLANO CO WA | VAL PMT =WT71 | 3NA | 900 | 900 | 900 | 1435 | 1435 | 1435 | 1435 | 1435 | 1435 | 1435 | 1435 | 747 | 14927 |
| *** TOTAL *** | | | 2500 | 2360 | 2565 | 3770 | 4150 | 4165 | 3960 | 3940 | 4360 | 3850 | 3470 | 2367 | 41457 |
| ZONE-7 ALAMEDA | M^I ENT=WT10 | 1SB | 15 | 14 | 19 | 28 | 40 | 47 | 58 | 60 | 55 | 44 | 19 | 15 | 414 |
| ZONE-7 ALAMEDA | M^I ENT=WT10 | 2SB | 450 | 440 | 350 | 590 | 860 | 870 | 920 | 840 | 760 | 500 | 590 | 630 | 7800 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 4SB | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 3480 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 4SB | 10 | 30 | 265 | 350 | 390 | 430 | 461 | 460 | 55 | 175 | 0 | 0 | 2626 |
| ZONE-7 ALAMEDA | WETMWTHR=WT87 | 4SB | 729 | 729 | 729 | 729 | 729 | 729 | 731 | 731 | 729 | 729 | 729 | 729 | 8752 |
| ZONE-7 ALAMEDA | M GW ENT=WT08 | 5SB | 287 | 288 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 290 | 287 | 287 | 3469 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 5SB | 0 | 0 | 0 | 15 | 40 | 40 | 40 | 25 | 0 | 10 | 0 | 0 | 170 |
| ZONE-7 ALAMEDA | WETMWTHR=WT87 | 5SB | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 104 | 1248 |
| ZONE-7 ALAMEDA | M^I ENT=WT10 | 6SB | 929 | 836 | 1300 | 1640 | 1903 | 1841 | 1903 | 1903 | 1841 | 1887 | 1058 | 810 | 17851 |
| ZONE-7 ALAMEDA | AGR ENT=WT01 | 6SB | 0 | 0 | 0 | 20 | 20 | 40 | 40 | 30 | 10 | 0 | 0 | 0 | 160 |
| *** TOTAL *** | | | 2814 | 2731 | 3347 | 4056 | 4666 | 4681 | 4837 | 4733 | 4134 | 4029 | 3077 | 2865 | 45970 |
| ALAMEDA CO WD | M GW ENT=WT08 | 7SB | 1530 | 1390 | 1840 | 2700 | 3070 | 3270 | 3380 | 3380 | 3270 | 2760 | 2080 | 1530 | 30200 |
| ALAMEDA CO WD | WETAWTHR=WT07 | 7SB | 0 | 0 | 0 | 0 | 200 | 200 | 350 | 350 | 300 | 300 | 200 | 200 | 2100 |
| ALAMEDA CO WD | M^I ENT=WT10 | 8SB | 824 | 744 | 824 | 797 | 824 | 797 | 824 | 824 | 797 | 824 | 797 | 824 | 9700 |
| *** TOTAL *** | | | 2354 | 2134 | 2664 | 3497 | 4094 | 4267 | 4554 | 4554 | 4367 | 3884 | 3077 | 2554 | 42000 |
| SANTA CLARA VWD | M^I ENT=WT10 | 9SB | 4400 | 4200 | 5300 | 7000 | 9000 | 9500 | 10000 | 9800 | 9200 | 7000 | 4700 | 4300 | 84400 |
| SANTA CLARA VWD | M GW ENT=WT08 | 9SB | 0 | 0 | 900 | 2600 | 1060 | 1020 | 560 | 760 | 1000 | 2500 | 1200 | 0 | 11600 |
| *** TOTAL *** | | | 4400 | 4200 | 6200 | 9600 | 10060 | 10520 | 10560 | 10560 | 10200 | 9500 | 5900 | 4300 | 96000 |
| SANTA BARBARA | M^I ENT=WT10 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DEVIL↑S DEN WD | 12D AGR=WT13 | 31A | 762 | 686 | 762 | 190 | 0 | 0 | 419 | 343 | 0 | 0 | 0 | 648 | 3810 |
| DEVIL↑S DEN WD | AGR SUR=WT04 | 31A | 698 | 628 | 698 | 175 | 0 | 0 | 384 | 314 | 0 | 0 | 0 | 593 | 3490 |
| *** TOTAL *** | | | 1460 | 1314 | 1460 | 365 | 0 | 0 | 803 | 657 | 0 | 0 | 0 | 1241 | 7300 |

FILE DUMP

FILE IDENTIFICATION: N199292 03/30/92. SHEET 2

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DUDLEY RIDGE WD | AGR ENT=WT01 | 8D | 2100 | 5200 | 2700 | 3400 | 6500 | 9600 | 10000 | 9400 | 2800 | 2500 | 1600 | 1900 | 57700 |
| DUDLEY RIDGE WD | 91DRBANK=WT91 | 8D | 800 | 700 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1500 |
| *** TOTAL *** | | | 2900 | 5900 | 2700 | 3400 | 6500 | 9600 | 10000 | 9400 | 2800 | 2500 | 1600 | 1900 | 59200 |
| EMPIRE WS ID | AGR ENT=WT01 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | 12D AGR=WT13 | 8C | 390 | 160 | 320 | 60 | 0 | 320 | 460 | 460 | 330 | 80 | 260 | 160 | 3000 |
| *** TOTAL *** | | | 450 | 250 | 500 | 300 | 300 | 800 | 1000 | 1000 | 600 | 200 | 350 | 250 | 6000 |
| KERN COUNTY WA | AGR ENT=WT01 | 9 | 3550 | 6390 | 7100 | 8520 | 7810 | 14200 | 19880 | 18750 | 4260 | 2840 | 710 | 4822 | 98832 |
| KERN COUNTY WA | M^I ENT=WT10 | 10A | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 1200 |
| KERN COUNTY WA | M GW ENT=WT08 | 10A | 0 | 150 | 300 | 0 | 300 | 800 | 800 | 1200 | 900 | 0 | 0 | 0 | 4450 |
| KERN COUNTY WA | AGR ENT=WT01 | 10A | 3898 | 20456 | 16938 | 16375 | 28582 | 45885 | 54143 | 50025 | 9588 | 2309 | 2091 | 4676 | 254966 |
| KERN COUNTY WA | X82 ORD=WT51 | 10A | 0 | 0 | 5758 | 6000 | 0 | 0 | 0 | 0 | 5000 | 5000 | 1348 | 1000 | 24106 |
| KERN COUNTY WA | M^I ENT=WT10 | 11B | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1162 | 15000 |
| KERN COUNTY WA | AGR ENT=WT01 | 11B | 2660 | 5320 | 10640 | 10640 | 13300 | 21280 | 31920 | 26600 | 5320 | 2660 | 1330 | 1426 | 133096 |
| KERN COUNTY WA | M^I ENT=WT10 | 12E | 2110 | 1990 | 2300 | 2490 | 3010 | 3220 | 3500 | 3450 | 2920 | 2610 | 2000 | 2110 | 31710 |
| KERN COUNTY WA | M GW ENT=WT08 | 12E | 450 | 750 | 1300 | 500 | 5030 | 13815 | 14355 | 17245 | 5825 | 5940 | 6320 | 6410 | 77940 |
| KERN COUNTY WA | AGR ENT=WT01 | 12E | 9181 | 19681 | 16092 | 12076 | 20300 | 31600 | 30150 | 29600 | 15300 | 1640 | 1640 | 1640 | 188900 |
| KERN COUNTY WA | 12D AGR=WT13 | 12E | 0 | 0 | 0 | 5263 | 7000 | 0 | 1350 | 2000 | 18459 | 21400 | 23900 | 20628 | 100000 |
| KERN COUNTY WA | 78MWD 30=WT16 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2047 | 6500 | 6500 | 6500 | 21547 |
| KERN COUNTY WA | X82 ORD=WT51 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1239 | 5000 | 5000 | 5000 | 16239 |
| KERN COUNTY WA | X82 MWD=WT52 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 323 | 1000 | 1000 | 1000 | 3323 |
| KERN COUNTY WA | AGR ENT=WT01 | 13B | 300 | 1400 | 1400 | 1400 | 2500 | 11000 | 11000 | 6500 | 0 | 0 | 0 | 8226 | 43726 |
| KERN COUNTY WA | X82 ORD=WT51 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6048 | 6048 |
| KERN COUNTY WA | M^I ENT=WT10 | 14A | 67 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 69 | 63 | 820 |
| KERN COUNTY WA | AGR ENT=WT01 | 14A | 200 | 2698 | 2498 | 1198 | 1898 | 4998 | 6598 | 4698 | 598 | 298 | 198 | 400 | 26280 |
| KERN COUNTY WA | M^I ENT=WT10 | 14B | 0 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 0 | 60 |
| KERN COUNTY WA | AGR ENT=WT01 | 14B | 700 | 7394 | 10194 | 5694 | 8194 | 12794 | 14394 | 12194 | 3294 | 2094 | 1394 | 1200 | 79540 |
| KERN COUNTY WA | M^I ENT=WT10 | 14C | 0 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 0 | 20 |
| KERN COUNTY WA | AGR ENT=WT01 | 14C | 1000 | 3598 | 2998 | 1998 | 3298 | 4998 | 6298 | 5198 | 1398 | 1198 | 798 | 1200 | 33980 |
| KERN COUNTY WA | M^I ENT=WT10 | 15A | 0 | 0 | 10 | 0 | 10 | 10 | 10 | 10 | 0 | 0 | 0 | 0 | 50 |
| KERN COUNTY WA | AGR ENT=WT01 | 15A | 700 | 600 | 3890 | 2400 | 5090 | 5490 | 6390 | 4490 | 2100 | 2400 | 900 | 1800 | 36250 |
| KERN COUNTY WA | M^I ENT=WT10 | 16A | 0 | 0 | 10 | 360 | 1002 | 970 | 998 | 10 | 0 | 0 | 0 | 0 | 3350 |
| KERN COUNTY WA | AGR ENT=WT01 | 16A | 100 | 100 | 590 | 600 | 790 | 1190 | 1494 | 1882 | 1260 | 944 | 580 | 500 | 10030 |
| KERN COUNTY WA | AGR ENT=WT01 | 31A | 2700 | 4000 | 5900 | 10800 | 17600 | 20100 | 19100 | 15100 | 8000 | 6800 | 0 | 3100 | 113200 |
| *** TOTAL *** | | | 28974 | 75962 | 89353 | 87749 | 127149 | 193785 | 223815 | 200387 | 89266 | 72068 | 57144 | 79011 | 1324663 |
| COUNTY OF KINGS | AGR ENT=WT01 | 8C | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| COUNTY OF KINGS | 12D AGR=WT13 | 8C | 335 | 335 | 335 | 335 | 335 | 335 | 335 | 335 | 330 | 330 | 330 | 330 | 4000 |
| *** TOTAL *** | | | 735 | 735 | 735 | 735 | 335 | 735 | 735 | 735 | 730 | 730 | 330 | 730 | 8000 |
| OAK FLAT WD | AGR ENT=WT01 | 2A | 64 | 171 | 342 | 456 | 627 | 1026 | 1026 | 1026 | 513 | 228 | 171 | 50 | 5700 |
| OAK FLAT WD | 12D AGR=WT13 | 2A | 0 | 0 | 108 | 273 | 423 | 238 | 324 | 134 | 0 | 0 | 0 | 0 | 1500 |
| *** TOTAL *** | | | 64 | 171 | 450 | 729 | 1050 | 1264 | 1350 | 1160 | 513 | 228 | 171 | 50 | 7200 |
| TULARE LK BWSD | AGR ENT=WT01 | 8C | 174 | 498 | 498 | 997 | 997 | 10682 | 12938 | 10812 | 692 | 0 | 2993 | 6119 | 47400 |
| TULARE LK BWSD | 12D AGR=WT13 | 8C | 1210 | 1540 | 1320 | 1100 | 1640 | 4060 | 4390 | 3290 | 990 | 770 | 1640 | 1760 | 23710 |
| TULARE LK BWSD | WETAWTHR=WT07 | 8C | 1640 | 2090 | 1790 | 1490 | 2240 | 5530 | 5980 | 4480 | 1340 | 1040 | 2240 | 2402 | 32262 |
| TULARE LK BWSD | AGR ENT=WT01 | 8D | 262 | 748 | 748 | 1496 | 1496 | 16024 | 19406 | 16219 | 1038 | 0 | 4488 | 9175 | 71100 |
| TULARE LK BWSD | 12D AGR=WT13 | 8D | 1810 | 2300 | 1970 | 1640 | 2470 | 6090 | 6580 | 4940 | 1480 | 1150 | 2470 | 2640 | 35540 |
| TULARE LK BWSD | WETAWTHR=WT07 | 8D | 2470 | 3140 | 2690 | 2240 | 3360 | 8290 | 8960 | 6720 | 2020 | 1570 | 3360 | 3580 | 48400 |

FILE DUMP

FILE IDENTIFICATION: N199292 03/30/92. SHEET 3

| AGENCY | WATER TYPE | | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *** TOTAL *** | | | | 7566 | 10316 | 9016 | 8963 | 12203 | 50676 | 58254 | 46461 | 7560 | 4530 | 17191 | 25676 | 258412 |
| AVEK WA | M^I | ENT=WT10 | 18A | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 4 | 5 | 6 | 7 | 8 | 39 |
| AVEK WA | M^I | ENT=WT10 | 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AVEK WA | AGR | ENT=WT01 | 19 | 7 | 7 | 58 | 162 | 185 | 210 | 220 | 175 | 172 | 61 | 46 | 11 | 1314 |
| AVEK WA | M^I | ENT=WT10 | 19C | 430 | 522 | 627 | 797 | 870 | 1061 | 1128 | 1110 | 918 | 714 | 530 | 490 | 9197 |
| AVEK WA | AGR | ENT=WT01 | 19C | 22 | 390 | 1221 | 1445 | 1648 | 1994 | 1887 | 1815 | 1312 | 741 | 145 | 122 | 12742 |
| AVEK WA | M^I | ENT=WT10 | 20A | 1641 | 1572 | 1920 | 2575 | 3330 | 3717 | 4398 | 3940 | 3390 | 3067 | 2635 | 2138 | 34323 |
| AVEK WA | AGR | ENT=WT01 | 20A | 8 | 8 | 9 | 12 | 16 | 20 | 20 | 20 | 15 | 10 | 8 | 8 | 154 |
| AVEK WA | M^I | ENT=WT10 | 20B | 70 | 65 | 120 | 170 | 230 | 230 | 240 | 255 | 210 | 200 | 160 | 150 | 2100 |
| AVEK WA | M^I | ENT=WT10 | 22A | 235 | 245 | 350 | 375 | 490 | 510 | 560 | 570 | 490 | 410 | 295 | 270 | 4800 |
| AVEK WA | AGR | ENT=WT01 | 22A | 10 | 20 | 80 | 100 | 125 | 140 | 250 | 220 | 100 | 50 | 10 | 5 | 1110 |
| *** TOTAL *** | | | | 2424 | 2830 | 4386 | 5637 | 6895 | 7883 | 8706 | 8109 | 6612 | 5259 | 3836 | 3202 | 65779 |
| CASTAIC LAKE WA | M^I | ENT=WT10 | 30 | 1414 | 747 | 1661 | 1884 | 2381 | 1994 | 3465 | 3016 | 3394 | 2293 | 1963 | 2592 | 26804 |
| CASTAIC LAKE WA | AGR | ENT=WT01 | 31A | 254 | 381 | 762 | 1016 | 1270 | 2032 | 2286 | 2286 | 1143 | 508 | 381 | 381 | 12700 |
| *** TOTAL *** | | | | 1668 | 1128 | 2423 | 2900 | 3651 | 4026 | 5751 | 5302 | 4537 | 2801 | 2344 | 2973 | 39504 |
| COACHELLA VALLY | M^I | ENT=WT10 | 26A | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 2024 | 23100 |
| *** TOTAL *** | | | | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 2024 | 23100 |
| CRESTLINE-LA WA | M^I | ENT=WT10 | 24 | 158 | 174 | 160 | 100 | 135 | 146 | 216 | 226 | 207 | 178 | 180 | 170 | 2050 |
| *** TOTAL *** | | | | 158 | 174 | 160 | 100 | 135 | 146 | 216 | 226 | 207 | 178 | 180 | 170 | 2050 |
| DESERT WA | M GW | ENT=WT08 | 26A | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| *** TOTAL *** | | | | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| LITTLEROCK CR | M^I | ENT=WT10 | 21 | 60 | 60 | 130 | 150 | 200 | 240 | 280 | 280 | 240 | 150 | 80 | 60 | 1930 |
| LITTLEROCK CR | AGR | ENT=WT01 | 21 | 0 | 0 | 30 | 40 | 50 | 60 | 60 | 60 | 40 | 30 | 0 | 0 | 370 |
| *** TOTAL *** | | | | 60 | 60 | 160 | 190 | 250 | 300 | 340 | 340 | 280 | 180 | 80 | 60 | 2300 |
| METROPOLITAN WD | STOR | ENT=WT60 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30000 | 30000 | 30000 | 30000 | 120000 |
| METROPOLITAN WD | M^I | ENT=WT10 | 26A | 9789 | 0 | 9789 | 4509 | 24669 | 23709 | 39549 | 39549 | 38109 | 17229 | 16509 | 17121 | 240531 |
| METROPOLITAN WD | M GW | ENT=WT08 | 26A | 22320 | 7509 | 22320 | 14400 | 7440 | 7200 | 11160 | 11160 | 10800 | 33480 | 32400 | 33480 | 213669 |
| METROPOLITAN WD | M^I | ENT=WT10 | 28H | 6000 | 6000 | 10000 | 11000 | 10000 | 10000 | 14100 | 14100 | 13700 | 10000 | 10000 | 10000 | 124900 |
| METROPOLITAN WD | BYPS | ENT=WT59 | 28H | 26200 | 23900 | 22200 | 20000 | 22200 | 25400 | 22500 | 22500 | 21700 | 22200 | 21000 | 22200 | 272000 |
| METROPOLITAN WD | M^I | ENT=WT10 | 28J | 400 | 400 | 400 | 400 | 400 | 5400 | 10400 | 10400 | 5400 | 400 | 400 | 400 | 34800 |
| METROPOLITAN WD | M^I | ENT=WT10 | 30 | 75300 | 70400 | 75300 | 72800 | 75300 | 72800 | 75300 | 75300 | 72800 | 75300 | 93700 | 96800 | 931100 |
| *** TOTAL *** | | | | 140009 | 108209 | 140009 | 123109 | 140009 | 144509 | 173009 | 173009 | 192509 | 188609 | 204009 | 210001 | 1937000 |
| MOJAVE WA | M GW | ENT=WT08 | 24 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 24000 |
| *** TOTAL *** | | | | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 24000 |
| PALMDALE WD | M^I | ENT=WT10 | 20B | 0 | 0 | 1450 | 1450 | 1600 | 1600 | 1600 | 1600 | 1450 | 1450 | 1000 | 0 | 13200 |
| *** TOTAL *** | | | | 0 | 0 | 1450 | 1450 | 1600 | 1600 | 1600 | 1600 | 1450 | 1450 | 1000 | 0 | 13200 |

STATE OF CALIFORNIA
THE RESOURCES AGENCY

FILE ID: M199393

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1993

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

DATE: 03/05/93
PAGE: 1

1993

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | TOTAL = | 1106 | | | | | | | | | | | | | |
| | TOT ENT = | 1106 | M&I | ENT = | 1106 | | | | | | | | | | |
| PLUMAS CO FCWCD | TOTAL = | 1160 | | | | | | | | | | | | | |
| | TOT ENT = | 1160 | M&I | ENT = | 1160 | | | | | | | | | | |
| YUBA CITY | TOTAL = | 2700 | | | | | | | | | | | | | |
| | TOT ENT = | 2700 | M&I | ENT = | 2700 | | | | | | | | | | |
| NAPA CO FCWCD | TOTAL = | 8490 | | | | | | | | | | | | | |
| | TOT ENT = | 8490 | M&I | ENT = | 8490 | | | | | | | | | | |
| SOLANO CO WA | TOTAL = | 44417 | | | | | | | | | | | | | |
| | TOT ENT = | 27130 | M&I | ENT = | 9600 | BEN ENT | = | 12730 | VAL ENT | = | 3800 | CYOVMENT | = | 1000 | |
| | TOT MISC = | 17287 | VAL | PMT = | 17287 | | | | | | | | | | |
| ZONE-7 ALAMEDA | TOTAL = | 46000 | | | | | | | | | | | | | |
| | TOT ENT = | 46000 | M&I | ENT = | 24677 | M GW ENT | = | 10413 | AGR ENT | = | 2910 | WETMWTHR | = | 8000 | |
| ALAMEDA CO WD | TOTAL = | 42000 | | | | | | | | | | | | | |
| | TOT ENT = | 42000 | M&I | ENT = | 24626 | M GW ENT | = | 16774 | WETAWTHR | = | 600 | | | | |
| SANTA CLARA VWD | TOTAL = | 98000 | | | | | | | | | | | | | |
| | TOT ENT = | 98000 | M&I | ENT = | 86000 | M GW ENT | = | 12000 | | | | | | | |
| DUDLEY RIDGE WD | TOTAL = | 58200 | | | | | | | | | | | | | |
| | TOT ENT = | 58200 | AGR | ENT = | 57700 | CYOV ENT | = | 500 | | | | | | | |
| EMPIRE WS ID | TOTAL = | 6000 | | | | | | | | | | | | | |
| | TOT ENT = | 6000 | AGR | ENT = | 3000 | 12D | AGR | = | 3000 | | | | | | |
| KERN COUNTY WA | TOTAL = | 1347313 | | | | | | | | | | | | | |
| | TOT ENT = | 1276050 | M&I | ENT = | 52810 | M GW ENT | = | 81790 | AGR ENT | = | 1018800 | 12D | AGR | = | 100000 |
| | TOT MISC = | 71263 | 78MWD | 30 = | 21547 | X82 | ORO | = | 46393 | X82 | MWD = | 3323 | | | |
| COUNTY OF KINGS | TOTAL = | 8200 | | | | | | | | | | | | | |
| | TOT ENT = | 8200 | AGR | ENT = | 4000 | 12D | AGR | = | 4200 | | | | | | |
| OAK FLAT WD | TOTAL = | 7200 | | | | | | | | | | | | | |
| | TOT ENT = | 5700 | AGR | ENT = | 5700 | | | | | | | | | | |
| | TOT SUR = | 1500 | AGR | SUR = | 1500 | | | | | | | | | | |
| TULARE LK BWSD | TOTAL = | 350000 | | | | | | | | | | | | | |
| | TOT ENT = | 262012 | AGR | ENT = | 118500 | 12D | AGR | = | 59250 | WETAWTHR | = | 80662 | CYOV ENT | = | 3600 |
| | TOT SUR = | 87988 | AGR | SUR = | 87988 | | | | | | | | | | |
| AVEK WA | TOTAL = | 53906 | | | | | | | | | | | | | |
| | TOT ENT = | 53906 | M&I | ENT = | 43778 | AGR | ENT | = | 10128 | | | | | | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CASTAIC LAKE WA | TOTAL = | 51653 | | | | | | | |
| | TOT ENT = | 48163 | M&I ENT = | 31653 | AGR ENT = | 12700 | 12D AGR = | 3810 | |
| | TOT SUR = | 3490 | AGR SUR = | 3490 | | | | | |
| COACHELLA VALLY | TOTAL = | 23100 | | | | | | | |
| | TOT ENT = | 23100 | M&I ENT = | 23100 | | | | | |
| CRESTLINE-LA WA | TOTAL = | 2350 | | | | | | | |
| | TOT ENT = | 2350 | M&I ENT = | 2350 | | | | | |
| DESERT WA | TOTAL = | 38100 | | | | | | | |
| | TOT ENT = | 38100 | M GW ENT = | 38100 | | | | | |
| LITTLEROCK CR | TOTAL = | 2300 | | | | | | | |
| | TOT ENT = | 2300 | M&I ENT = | 1930 | AGR ENT = | 370 | | | |
| METROPOLITAN WD | TOTAL = | 2011500 | | | | | | | |
| | TOT ENT = | 2011500 | M&I ENT = | 1525780 | M GW ENT = | 213720 | BYPS ENT = | 272000 | |
| MOJAVE WA | TOTAL = | 36000 | | | | | | | |
| | TOT ENT = | 36000 | M GW ENT = | 36000 | | | | | |
| PALMDALE WD | TOTAL = | 16200 | | | | | | | |
| | TOT ENT = | 16200 | M&I ENT = | 14300 | CYOVMENT = | 1900 | | | |
| SAN BERNARDINO | TOTAL = | 32000 | | | | | | | |
| | TOT ENT = | 32000 | M&I ENT = | 12000 | M GW ENT = | 20000 | | | |
| SAN GABRIEL | TOTAL = | 24000 | | | | | | | |
| | TOT ENT = | 24000 | M GW ENT = | 24000 | | | | | |
| VENTURA CO FCD | TOTAL = | 5000 | | | | | | | |
| | TOT ENT = | 5000 | M GW ENT = | 5000 | | | | | |
| SHELL CAL PROD. | TOTAL = | 11040 | | | | | | | |
| | TOT MISC = | 11040 | REPAYMNT = | 11040 | | | | | |
| JG BOSWELL | TOTAL = | 9000 | | | | | | | |
| | TOT MISC = | 9000 | REPAYMNT = | 9000 | | | | | |
| FISH & GAME | TOTAL = | 660 | | | | | | | |
| | TOT MISC = | 660 | REC/F&WL = | 660 | | | | | |
| PARKS & RECREAT | TOTAL = | 90 | | | | | | | |
| | TOT MISC = | 90 | REC/F&WL = | 90 | | | | | |
| REC/FISH&WILDLF | TOTAL = | 7460 | | | | | | | |
| | TOT MISC = | 7460 | REC/F&WL = | 7460 | | | | | |

| | | | |
|---|---|---|---|
| FRESNO COUNTY | TOTAL = | 3000 | |
| | TOT MISC = | 3000 | CVC WLNG = 3000 |
| HILLS VALLEY ID | TOTAL = | 3346 | |
| | TOT MISC = | 3346 | CVC WLNG = 3346 |
| KERN-TULARE WD | TOTAL = | 40000 | |
| | TOT MISC = | 40000 | CVC WLNG = 40000 |
| LOWER TULE RIVR | TOTAL = | 31102 | |
| | TOT MISC = | 31102 | CVC WLNG = 31102 |
| PIXLEY ID | TOTAL = | 31102 | |
| | TOT MISC = | 31102 | CVC WLNG = 31102 |
| RAG GULCH WD | TOTAL = | 13300 | |
| | TOT MISC = | 13300 | CVC WLNG = 13300 |
| TRI-VALLEY WD | TOTAL = | 1142 | |
| | TOT MISC = | 1142 | CVC WLNG = 1142 |
| TULARE COUNTY | TOTAL = | 5308 | |
| | TOT MISC = | 5308 | CVC WLNG = 5308 |

FILE DUMP

FILE IDENTIFICATION: M199393 03/05/93. SHEET 1

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT010 | FR | 70 | 55 | 505 | 205 | 57 | 52 | 12 | 12 | 12 | 12 | 27 | 87 | 1106 |
| *** TOTAL *** | | | 70 | 55 | 505 | 205 | 57 | 52 | 12 | 12 | 12 | 12 | 27 | 87 | 1106 |
| PLUMAS CO FCWCD | M&I ENT=WT010 | FR | 36 | 41 | 45 | 83 | 114 | 162 | 180 | 180 | 180 | 51 | 45 | 43 | 1160 |
| *** TOTAL *** | | | 36 | 41 | 45 | 83 | 114 | 162 | 180 | 180 | 180 | 51 | 45 | 43 | 1160 |
| YUBA CITY | M&I ENT=WT010 | FR | 0 | 0 | 0 | 0 | 0 | 400 | 800 | 800 | 500 | 200 | 0 | 0 | 2700 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 400 | 800 | 800 | 500 | 200 | 0 | 0 | 2700 |
| NAPA CO FCWCD | M&I ENT=WT010 | 3NB | 574 | 419 | 474 | 676 | 814 | 877 | 927 | 877 | 799 | 746 | 649 | 658 | 8490 |
| *** TOTAL *** | | | 574 | 419 | 474 | 676 | 814 | 877 | 927 | 877 | 799 | 746 | 649 | 658 | 8490 |
| SOLANO CO WA | CYOVMENT=WT077 | 1NB | 0 | 0 | 0 | 0 | 0 | 300 | 100 | 200 | 0 | 0 | 0 | 0 | 600 |
| SOLANO CO WA | M&I ENT=WT010 | 1NB | 470 | 535 | 535 | 880 | 1000 | 1050 | 1050 | 1050 | 1050 | 905 | 575 | 500 | 9600 |
| SOLANO CO WA | VAL PMT =WT071 | 1NB | 0 | 0 | 0 | 40 | 240 | 255 | 500 | 500 | 350 | 255 | 220 | 0 | 2360 |
| SOLANO CO WA | CYOVMENT=WT077 | 3NA | 0 | 0 | 0 | 0 | 0 | 0 | 400 | 0 | 0 | 0 | 0 | 0 | 400 |
| SOLANO CO WA | BEN ENT =WT046 | 3NA | 925 | 730 | 940 | 1090 | 1175 | 1075 | 1250 | 1240 | 1175 | 1145 | 1065 | 920 | 12730 |
| SOLANO CO WA | VAL ENT =WT047 | 3NA | 300 | 300 | 300 | 330 | 330 | 340 | 340 | 330 | 330 | 300 | 300 | 300 | 3800 |
| SOLANO CO WA | VAL PMT =WT071 | 3NA | 900 | 900 | 900 | 1435 | 1435 | 1435 | 1435 | 1435 | 1435 | 1435 | 1435 | 747 | 14927 |
| *** TOTAL *** | | | 2595 | 2465 | 2675 | 3775 | 4180 | 4455 | 5075 | 4755 | 4340 | 4040 | 3595 | 2467 | 44417 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 1SB | 15 | 14 | 19 | 29 | 39 | 46 | 58 | 60 | 55 | 45 | 18 | 15 | 413 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 2SB | 426 | 414 | 481 | 618 | 833 | 890 | 958 | 934 | 850 | 730 | 513 | 442 | 8089 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 4SB | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 682 | 8184 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 4SB | 31 | 34 | 117 | 261 | 411 | 530 | 531 | 393 | 47 | 146 | 33 | 31 | 2565 |
| ZONE-7 ALAMEDA | WETMWTHR=WT087 | 4SB | 524 | 524 | 524 | 524 | 524 | 524 | 524 | 524 | 524 | 524 | 524 | 524 | 6288 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 5SB | 184 | 186 | 186 | 186 | 186 | 186 | 186 | 186 | 186 | 186 | 186 | 185 | 2229 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 5SB | 0 | 0 | 0 | 20 | 50 | 50 | 50 | 30 | 0 | 10 | 0 | 0 | 210 |
| ZONE-7 ALAMEDA | WETMWTHR=WT087 | 5SB | 141 | 143 | 143 | 143 | 143 | 143 | 143 | 143 | 143 | 143 | 143 | 141 | 1712 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 6SB | 852 | 828 | 962 | 1237 | 1665 | 1780 | 1915 | 1868 | 1699 | 1460 | 1026 | 883 | 16175 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 6SB | 0 | 0 | 0 | 5 | 25 | 35 | 35 | 25 | 5 | 5 | 0 | 0 | 135 |
| *** TOTAL *** | | | 2855 | 2825 | 3114 | 3705 | 4558 | 4866 | 5082 | 4845 | 4191 | 3931 | 3125 | 2903 | 46000 |
| ALAMEDA CO WD | M GW ENT=WT008 | 7SB | 0 | 0 | 0 | 2260 | 2460 | 2470 | 2560 | 2560 | 2380 | 2084 | 0 | 0 | 16774 |
| ALAMEDA CO WD | WETAWTHR=WT007 | 7SB | 0 | 0 | 0 | 0 | 0 | 200 | 200 | 200 | 0 | 0 | 0 | 0 | 600 |
| ALAMEDA CO WD | M&I ENT=WT010 | 8SB | 809 | 730 | 809 | 1427 | 1475 | 2716 | 2807 | 2807 | 2716 | 2807 | 2716 | 2807 | 24626 |
| *** TOTAL *** | | | 809 | 730 | 809 | 3687 | 3935 | 5386 | 5567 | 5567 | 5096 | 4891 | 2716 | 2807 | 42000 |
| SANTA CLARA VWD | M&I ENT=WT010 | 9SB | 4400 | 4200 | 4300 | 5200 | 9000 | 9500 | 10200 | 10000 | 9400 | 7500 | 7000 | 5300 | 86000 |
| SANTA CLARA VWD | M GW ENT=WT008 | 9SB | 0 | 0 | 1000 | 2660 | 1260 | 1100 | 540 | 740 | 1000 | 2500 | 1200 | 0 | 12000 |
| *** TOTAL *** | | | 4400 | 4200 | 5300 | 7860 | 10260 | 10600 | 10740 | 10740 | 10400 | 10000 | 8200 | 5300 | 98000 |
| DUDLEY RIDGE WD | AGR ENT=WT001 | 8D | 2400 | 5600 | 2700 | 3400 | 6500 | 9600 | 10000 | 9900 | 2400 | 2200 | 1500 | 1500 | 57700 |
| DUDLEY RIDGE WD | CYOV ENT=WT069 | 8D | 209 | 291 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 500 |
| *** TOTAL *** | | | 2609 | 5891 | 2700 | 3400 | 6500 | 9600 | 10000 | 9900 | 2400 | 2200 | 1500 | 1500 | 58200 |
| EMPIRE WS ID | AGR ENT=WT001 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |

FILE DUMP

FILE IDENTIFICATION: M199393 03/05/93. SHEET 2

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EMPIRE WS ID | 12D AGR=WT013 | 8C | 390 | 160 | 320 | 60 | 0 | 320 | 460 | 460 | 330 | 80 | 260 | 160 | 3000 |
| *** TOTAL *** | | | 450 | 250 | 500 | 300 | 300 | 800 | 1000 | 1000 | 600 | 200 | 350 | 250 | 6000 |
| KERN COUNTY WA | AGR ENT=WT001 | 9 | 0 | 0 | 2425 | 7800 | 9200 | 17750 | 23450 | 23155 | 4260 | 2840 | 2840 | 4500 | 98220 |
| KERN COUNTY WA | CYOV ENT=WT069 | 9 | 2150 | 2150 | 3255 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7555 |
| KERN COUNTY WA | M&I ENT=WT010 | 10A | 0 | 0 | 0 | 150 | 200 | 300 | 325 | 350 | 200 | 175 | 150 | 150 | 2000 |
| KERN COUNTY WA | AGR ENT=WT001 | 10A | 2448 | 17996 | 13348 | 16095 | 29492 | 48135 | 56373 | 53385 | 10488 | 2309 | 2961 | 4198 | 257228 |
| KERN COUNTY WA | CYOV ENT=WT069 | 10A | 950 | 950 | 3435 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5335 |
| KERN COUNTY WA | X82 ORO=WT051 | 10A | 0 | 0 | 5758 | 6000 | 0 | 0 | 0 | 0 | 5000 | 5000 | 1348 | 1000 | 24106 |
| KERN COUNTY WA | M&I ENT=WT010 | 11B | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1162 | 15000 |
| KERN COUNTY WA | AGR ENT=WT001 | 11B | 60 | 5320 | 10640 | 10640 | 13300 | 22280 | 32920 | 27200 | 5320 | 2660 | 1330 | 1426 | 133096 |
| KERN COUNTY WA | CYOV ENT=WT069 | 11B | 2600 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2600 |
| KERN COUNTY WA | M&I ENT=WT010 | 12E | 2110 | 1990 | 2300 | 2490 | 3010 | 3220 | 3500 | 3450 | 2920 | 2610 | 2000 | 2110 | 31710 |
| KERN COUNTY WA | M GW ENT=WT008 | 12E | 450 | 900 | 1600 | 500 | 5130 | 14115 | 15255 | 18445 | 6725 | 5940 | 6320 | 6410 | 81790 |
| KERN COUNTY WA | AGR ENT=WT001 | 12E | 17005 | 53531 | 41792 | 24076 | 21000 | 31400 | 29350 | 28400 | 14400 | 1640 | 1640 | 1640 | 265874 |
| KERN COUNTY WA | 12D AGR=WT013 | 12E | 0 | 0 | 0 | 5263 | 7000 | 0 | 1350 | 2000 | 18459 | 21400 | 23900 | 20628 | 100000 |
| KERN COUNTY WA | 78MWD 30=WT016 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2047 | 6500 | 6500 | 6500 | 21547 |
| KERN COUNTY WA | X82 ORO=WT051 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1239 | 5000 | 5000 | 5000 | 16239 |
| KERN COUNTY WA | X82 MWD=WT052 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 323 | 1000 | 1000 | 1000 | 3323 |
| KERN COUNTY WA | AGR ENT=WT001 | 13B | 4000 | 1500 | 1500 | 1500 | 3000 | 10000 | 10000 | 7000 | 0 | 0 | 0 | 4202 | 42702 |
| KERN COUNTY WA | X82 ORO=WT051 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6048 | 6048 |
| KERN COUNTY WA | M&I ENT=WT010 | 14A | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 63 | 800 |
| KERN COUNTY WA | AGR ENT=WT001 | 14A | 0 | 0 | 2400 | 2200 | 1900 | 3400 | 4000 | 3500 | 1000 | 600 | 100 | 100 | 19200 |
| KERN COUNTY WA | CYOV ENT=WT069 | 14A | 300 | 500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 800 |
| KERN COUNTY WA | AGR ENT=WT001 | 14B | 0 | 1500 | 4500 | 4800 | 7600 | 9500 | 9600 | 9000 | 2500 | 1200 | 700 | 400 | 51300 |
| KERN COUNTY WA | CYOV ENT=WT069 | 14B | 1200 | 500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1700 |
| KERN COUNTY WA | AGR ENT=WT001 | 14C | 0 | 1500 | 3500 | 2200 | 4000 | 4200 | 4000 | 3800 | 1800 | 1000 | 600 | 300 | 26900 |
| KERN COUNTY WA | CYOV ENT=WT069 | 14C | 1000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 |
| KERN COUNTY WA | AGR ENT=WT001 | 15A | 1500 | 1700 | 3000 | 2700 | 4800 | 6400 | 4500 | 3000 | 1300 | 2500 | 1300 | 1800 | 34500 |
| KERN COUNTY WA | M&I ENT=WT010 | 16A | 0 | 0 | 0 | 360 | 992 | 960 | 988 | 0 | 0 | 0 | 0 | 0 | 3300 |
| KERN COUNTY WA | AGR ENT=WT001 | 16A | 100 | 200 | 600 | 700 | 1300 | 1500 | 1004 | 1792 | 1260 | 1244 | 780 | 300 | 10780 |
| KERN COUNTY WA | AGR ENT=WT001 | 31A | 4000 | 4000 | 4000 | 5000 | 10000 | 15000 | 15000 | 8000 | 5000 | 4600 | 2600 | 1800 | 79000 |
| KERN COUNTY WA | CYOV ENT=WT069 | 31A | 1000 | 660 | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3660 |
| *** TOTAL *** | | | 42198 | 96222 | 107378 | 93799 | 123249 | 189485 | 212940 | 193802 | 85566 | 69543 | 62394 | 70737 | 1347313 |
| COUNTY OF KINGS | AGR ENT=WT001 | 8C | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| COUNTY OF KINGS | 12D AGR=WT013 | 8C | 400 | 400 | 400 | 400 | 100 | 400 | 400 | 400 | 400 | 400 | 100 | 400 | 4200 |
| *** TOTAL *** | | | 800 | 800 | 800 | 800 | 100 | 800 | 800 | 800 | 800 | 800 | 100 | 800 | 8200 |
| OAK FLAT WD | AGR ENT=WT001 | 2A | 64 | 171 | 342 | 456 | 627 | 1026 | 1026 | 1026 | 513 | 228 | 171 | 50 | 5700 |
| OAK FLAT WD | AGR SUR=WT004 | 2A | 0 | 0 | 108 | 273 | 423 | 238 | 324 | 134 | 0 | 0 | 0 | 0 | 1500 |
| *** TOTAL *** | | | 64 | 171 | 450 | 729 | 1050 | 1264 | 1350 | 1160 | 513 | 228 | 171 | 50 | 7200 |
| TULARE LK BWSD | AGR ENT=WT001 | 8C | 2548 | 0 | 333 | 333 | 1807 | 8532 | 8532 | 8532 | 3195 | 2068 | 5388 | 6132 | 47400 |
| TULARE LK BWSD | 12D AGR=WT013 | 8C | 1208 | 1536 | 1316 | 1096 | 1644 | 4060 | 4388 | 3292 | 988 | 768 | 1644 | 1760 | 23700 |
| TULARE LK BWSD | WETAWTHR=WT007 | 8C | 1644 | 2092 | 1792 | 1492 | 2240 | 5528 | 5976 | 4480 | 1344 | 1044 | 2240 | 2393 | 32265 |
| TULARE LK BWSD | CYOV ENT=WT069 | 8C | 1152 | 288 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1440 |
| TULARE LK BWSD | AGR SUR=WT004 | 8C | 3176 | 3112 | 428 | 952 | 11523 | 921 | 145 | 2632 | 1376 | 1780 | 2072 | 7078 | 35195 |
| TULARE LK BWSD | AGR ENT=WT001 | 8D | 3823 | 0 | 499 | 499 | 2711 | 12798 | 12798 | 12798 | 4792 | 3102 | 8082 | 9198 | 71100 |
| TULARE LK BWSD | 12D AGR=WT013 | 8D | 1812 | 2304 | 1974 | 1644 | 2466 | 6090 | 6582 | 4938 | 1482 | 1152 | 2466 | 2640 | 35550 |
| TULARE LK BWSD | WETAWTHR=WT007 | 8D | 2466 | 3138 | 2688 | 2238 | 3360 | 8292 | 8964 | 6720 | 2016 | 1566 | 3360 | 3589 | 48397 |
| TULARE LK BWSD | CYOV ENT=WT069 | 8D | 1728 | 432 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2160 |

FILE IDENTIFICATION: M199393 FILE DUMP 03/05/93. SHEET 3

| AGENCY | WATER TYPE | | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TULARE LK BWSD | AGR | SUR=WT004 | 8D | 4764 | 4668 | 642 | 1428 | 17284 | 1382 | 218 | 3948 | 2064 | 2670 | 3108 | 10617 | 52793 |
| *** TOTAL *** | | | | 24321 | 17570 | 9672 | 9682 | 43035 | 47603 | 47603 | 47340 | 17257 | 14150 | 28360 | 43407 | 350000 |
| AVEK WA | M&I | ENT=WT010 | 18A | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 144 |
| AVEK WA | AGR | ENT=WT001 | 19 | 5 | 5 | 27 | 42 | 65 | 90 | 105 | 120 | 117 | 65 | 51 | 21 | 713 |
| AVEK WA | M&I | ENT=WT010 | 19C | 405 | 390 | 435 | 560 | 670 | 875 | 950 | 1005 | 785 | 545 | 560 | 430 | 7610 |
| AVEK WA | AGR | ENT=WT001 | 19C | 11 | 141 | 576 | 968 | 1008 | 1376 | 1562 | 1202 | 971 | 635 | 181 | 26 | 8657 |
| AVEK WA | M&I | ENT=WT010 | 20A | 600 | 850 | 910 | 1950 | 2735 | 3425 | 4495 | 5265 | 3275 | 2775 | 2415 | 1560 | 30255 |
| AVEK WA | AGR | ENT=WT001 | 20A | 0 | 0 | 9 | 12 | 16 | 20 | 20 | 20 | 15 | 10 | 8 | 8 | 138 |
| AVEK WA | M&I | ENT=WT010 | 20B | 35 | 35 | 60 | 65 | 80 | 85 | 100 | 130 | 130 | 125 | 70 | 50 | 965 |
| AVEK WA | M&I | ENT=WT010 | 22A | 185 | 150 | 330 | 290 | 355 | 550 | 620 | 700 | 485 | 455 | 395 | 285 | 4800 |
| AVEK WA | AGR | ENT=WT001 | 22A | 0 | 0 | 0 | 60 | 110 | 100 | 135 | 135 | 60 | 20 | 0 | 0 | 620 |
| AVEK WA | M&I | ENT=WT010 | 29F | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| *** TOTAL *** | | | | 1253 | 1583 | 2359 | 3959 | 5055 | 6533 | 7999 | 8589 | 5850 | 4642 | 3692 | 2392 | 53906 |
| CASTAIC LAKE WA | M&I | ENT=WT010 | 30 | 1921 | 1782 | 2352 | 2520 | 2874 | 3118 | 3320 | 3349 | 3222 | 2811 | 2080 | 2304 | 31653 |
| CASTAIC LAKE WA | AGR | ENT=WT001 | 31A | 254 | 381 | 762 | 1016 | 1270 | 2032 | 2286 | 2286 | 1143 | 508 | 381 | 381 | 12700 |
| CASTAIC LAKE WA | 12D | AGR=WT013 | 31A | 762 | 686 | 762 | 190 | 0 | 0 | 419 | 343 | 0 | 0 | 0 | 648 | 3810 |
| CASTAIC LAKE WA | AGR | SUR=WT004 | 31A | 698 | 628 | 698 | 175 | 0 | 0 | 384 | 314 | 0 | 0 | 0 | 593 | 3490 |
| *** TOTAL *** | | | | 3635 | 3477 | 4574 | 3901 | 4144 | 5150 | 6409 | 6292 | 4365 | 3319 | 2461 | 3926 | 51653 |
| COACHELLA VALLY | M&I | ENT=WT010 | 26A | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 2024 | 23100 |
| *** TOTAL *** | | | | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 1916 | 2024 | 23100 |
| CRESTLINE-LA WA | M&I | ENT=WT010 | 24 | 181 | 200 | 183 | 115 | 155 | 167 | 248 | 259 | 237 | 204 | 206 | 195 | 2350 |
| *** TOTAL *** | | | | 181 | 200 | 183 | 115 | 155 | 167 | 248 | 259 | 237 | 204 | 206 | 195 | 2350 |
| DESERT WA | M GW | ENT=WT008 | 26A | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| *** TOTAL *** | | | | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| LITTLEROCK CR | M&I | ENT=WT010 | 21 | 60 | 60 | 130 | 150 | 200 | 240 | 280 | 280 | 240 | 150 | 80 | 60 | 1930 |
| LITTLEROCK CR | AGR | ENT=WT001 | 21 | 0 | 0 | 30 | 40 | 50 | 60 | 60 | 60 | 40 | 30 | 0 | 0 | 370 |
| *** TOTAL *** | | | | 60 | 60 | 160 | 190 | 250 | 300 | 340 | 340 | 280 | 180 | 80 | 60 | 2300 |
| METROPOLITAN WD | M&I | ENT=WT010 | 26A | 19789 | 9949 | 7589 | 26709 | 34669 | 33709 | 49549 | 49549 | 41509 | 33629 | 26509 | 21521 | 354680 |
| METROPOLITAN WD | M GW | ENT=WT008 | 26A | 22320 | 7560 | 22320 | 14400 | 7440 | 7200 | 11160 | 11160 | 10800 | 33480 | 32400 | 33480 | 213720 |
| METROPOLITAN WD | M&I | ENT=WT010 | 28H | 6000 | 6000 | 10000 | 11000 | 10000 | 10000 | 14100 | 14100 | 13700 | 10000 | 10000 | 10000 | 124900 |
| METROPOLITAN WD | BYPS | ENT=WT059 | 28H | 26200 | 23900 | 20000 | 22200 | 22200 | 25400 | 22500 | 22500 | 21700 | 22200 | 21000 | 22200 | 272000 |
| METROPOLITAN WD | M&I | ENT=WT010 | 28J | 400 | 400 | 400 | 400 | 400 | 5400 | 10400 | 10400 | 5400 | 400 | 400 | 400 | 34800 |
| METROPOLITAN WD | M&I | ENT=WT010 | 30 | 75300 | 86800 | 96800 | 93700 | 75300 | 77800 | 85300 | 80300 | 72800 | 96800 | 83700 | 86800 | 1011400 |
| *** TOTAL *** | | | | 150009 | 134609 | 157109 | 168409 | 150009 | 159509 | 193009 | 188009 | 165909 | 196509 | 174009 | 174401 | 2011500 |
| MOJAVE WA | M GW | ENT=WT008 | 24 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 36000 |
| *** TOTAL *** | | | | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 36000 |
| PALMDALE WD | CYOVMENT | =WT077 | 20B | 0 | 900 | 300 | 300 | 100 | 100 | 100 | 100 | 0 | 0 | 0 | 0 | 1900 |
| PALMDALE WD | M&I | ENT=WT010 | 20B | 0 | 0 | 1500 | 1500 | 1700 | 1700 | 1700 | 1700 | 1500 | 1500 | 1500 | 0 | 14300 |

```
COUNTY OF BUTTE TOTAL =    1101
            TOT  ENT =    1101  M&I  ENT =    1101
PLUMAS CO FCWCD TOTAL =    1200
            TOT  ENT =    1200  M&I  ENT =    1200
YUBA CITY       TOTAL =    2700
            TOT  ENT =    2700  M&I  ENT =    2700
NAPA CO FCWCD   TOTAL =    9135
            TOT  ENT =    9135  M&I  ENT =    9135
SOLANO CO WA    TOTAL =   45367
            TOT  ENT =   28080  M&I  ENT =   11150  BEN ENT  =   13130  VAL ENT  =    3800
            TOT MISC =   17287  VAL PMT  =   17287
ZONE-7 ALAMEDA  TOTAL =   48793
            TOT  ENT =   42551  M&I  ENT =   27458  M GW ENT =    8329  AGR  ENT =    4213  CYOVMENT =    2551
            TOT MISC =    6242  LOCAL    =    6242
ALAMEDA CO WD   TOTAL =   42001
            TOT  ENT =   42001  M&I  ENT =   24419  M GW ENT =   17582
SANTA CLARA VWD TOTAL =  100000
            TOT  ENT =  100000  M&I  ENT =   88000  M GW ENT =   12000
DUDLEY RIDGE WD TOTAL =   57700
            TOT  ENT =   57700  AGR  ENT =   57700
EMPIRE WS ID    TOTAL =    6000
            TOT  ENT =    6000  AGR  ENT =    3000  12D  AGR =    3000
KERN COUNTY WA  TOTAL = 1324663
            TOT  ENT = 1253400  M&I  ENT =   52710  M GW ENT =   81890  AGR  ENT = 1018800  12D  AGR =  100000
            TOT MISC =   71263  78MWD 30 =   21547  X82  ORD =   46393  X82  MWD =    3323
COUNTY OF KINGS TOTAL =    8200
            TOT  ENT =    8200  AGR  ENT =    4000  12D  AGR =    4200
OAK FLAT WD     TOTAL =    6200
            TOT  ENT =    6200  AGR  ENT =    5700  12D  AGR =     500
TULARE LK BWSD  TOTAL =  272812
            TOT  ENT =  258412  AGR  ENT =  118500  12D  AGR =   59250  WETAWTHR =   80662
            TOT  SUR =   14400  AGR  SUR =   14400
AVEK WA         TOTAL =   55902
            TOT  ENT =   55902  M&I  ENT =   45774  AGR  ENT =   10128
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| CASTAIC LAKE WA | TOTAL = | 45100 | | | | | | | |
| | TOT ENT = | 41610 | M&I | ENT = | 25100 | AGR ENT = | 12700 | 12D AGR = | 3810 |
| | TOT SUR = | 3490 | AGR | SUR = | 3490 | | | | |
| COACHELLA VALLY | TOTAL = | 23100 | | | | | | | |
| | TOT ENT = | 23100 | M&I | ENT = | 23100 | | | | |
| CRESTLINE-LA WA | TOTAL = | 1950 | | | | | | | |
| | TOT ENT = | 1950 | M&I | ENT = | 1950 | | | | |
| DESERT WA | TOTAL = | 38100 | | | | | | | |
| | TOT ENT = | 38100 | M GW | ENT = | 38100 | | | | |
| LITTLEROCK CR | TOTAL = | 2300 | | | | | | | |
| | TOT ENT = | 2300 | M&I | ENT = | 1930 | AGR ENT = | 370 | | |
| METROPOLITAN WD | TOTAL = | 2011500 | | | | | | | |
| | TOT ENT = | 2011500 | M&I | ENT = | 1525780 | M GW ENT = | 213720 | BYPS ENT = | 272000 |
| MOJAVE WA | TOTAL = | 50800 | | | | | | | |
| | TOT ENT = | 50800 | M GW | ENT = | 50800 | | | | |
| PALMDALE WD | TOTAL = | 15060 | | | | | | | |
| | TOT ENT = | 15060 | M&I | ENT = | 15060 | | | | |
| SAN BERNARDINO | TOTAL = | 30000 | | | | | | | |
| | TOT ENT = | 30000 | M&I | ENT = | 12000 | M GW ENT = | 18000 | | |
| SAN GABRIEL | TOTAL = | 16000 | | | | | | | |
| | TOT ENT = | 16000 | M GW | ENT = | 16000 | | | | |
| VENTURA CO FCD | TOTAL = | 5000 | | | | | | | |
| | TOT ENT = | 5000 | M GW | ENT = | 5000 | | | | |
| SHELL CAL PROD. | TOTAL = | 11040 | | | | | | | |
| | TOT MISC = | 11040 | REPAYMNT | = | 11040 | | | | |
| JG BOSWELL | TOTAL = | 14170 | | | | | | | |
| | TOT MISC = | 14170 | REPAYMNT | = | 14170 | | | | |
| FISH & GAME | TOTAL = | 1000 | | | | | | | |
| | TOT MISC = | 1000 | REC/F&WL | = | 1000 | | | | |
| PARKS & RECREAT | TOTAL = | 189 | | | | | | | |
| | TOT MISC = | 189 | REC/F&WL | = | 189 | | | | |
| REC/FISH&WILDLF | TOTAL = | 7460 | | | | | | | |
| | TOT MISC = | 7460 | REC/F&WL | = | 7460 | | | | |



| | | | | | |
|---|---|---|---|---|---|
| FRESNO COUNTY | TOTAL = | 3000 | | | |
| | TOT MISC = | 3000 | CVC WLNG | = | 3000 |

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT010 | FR | 65 | 55 | 505 | 205 | 57 | 52 | 12 | 12 | 12 | 12 | 27 | 87 | 1101 |
| *** TOTAL *** | | | 65 | 55 | 505 | 205 | 57 | 52 | 12 | 12 | 12 | 12 | 27 | 87 | 1101 |
| PLUMAS CO FCWCD | M&I ENT=WT010 | FR | 36 | 36 | 36 | 120 | 150 | 180 | 180 | 150 | 120 | 96 | 48 | 48 | 1200 |
| *** TOTAL *** | | | 36 | 36 | 36 | 120 | 150 | 180 | 180 | 150 | 120 | 96 | 48 | 48 | 1200 |
| YUBA CITY | M&I ENT=WT010 | FR | 0 | 0 | 0 | 0 | 0 | 400 | 800 | 800 | 500 | 200 | 0 | 0 | 2700 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 400 | 800 | 800 | 500 | 200 | 0 | 0 | 2700 |
| NAPA CO FCWCD | M&I ENT=WT010 | 3NB | 636 | 432 | 491 | 706 | 912 | 980 | 980 | 980 | 867 | 768 | 715 | 668 | 9135 |
| *** TOTAL *** | | | 636 | 432 | 491 | 706 | 912 | 980 | 980 | 980 | 867 | 768 | 715 | 668 | 9135 |
| SOLANO CO WA | M&I ENT=WT010 | 1NB | 535 | 610 | 610 | 1025 | 1165 | 1225 | 1230 | 1230 | 1225 | 1055 | 665 | 575 | 11150 |
| SOLANO CO WA | VAL PMT =WT071 | 1NB | 0 | 0 | 0 | 40 | 240 | 255 | 500 | 500 | 350 | 255 | 220 | 0 | 2360 |
| SOLANO CO WA | BEN ENT =WT046 | 3NA | 955 | 750 | 970 | 1125 | 1215 | 1110 | 1290 | 1275 | 1215 | 1180 | 1095 | 950 | 13130 |
| SOLANO CO WA | VAL ENT =WT047 | 3NA | 300 | 300 | 300 | 330 | 330 | 340 | 340 | 330 | 330 | 300 | 300 | 300 | 3800 |
| SOLANO CO WA | VAL PMT =WT071 | 3NA | 900 | 900 | 900 | 1435 | 1435 | 1435 | 1435 | 1435 | 1435 | 1435 | 1435 | 747 | 14927 |
| *** TOTAL *** | | | 2690 | 2560 | 2780 | 3955 | 4385 | 4365 | 4795 | 4770 | 4555 | 4225 | 3715 | 2572 | 45367 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 1SB | 19 | 20 | 22 | 37 | 57 | 64 | 67 | 69 | 64 | 53 | 24 | 19 | 515 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 2SB | 0 | 0 | 0 | 673 | 979 | 1100 | 1142 | 1142 | 977 | 808 | 579 | 500 | 7900 |
| ZONE-7 ALAMEDA | CYOVMENT=WT077 | 4SB | 1176 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1176 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 4SB | 0 | 597 | 595 | 595 | 595 | 595 | 595 | 595 | 595 | 1198 | 1193 | 1176 | 8329 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 4SB | 49 | 80 | 250 | 374 | 435 | 458 | 489 | 439 | 368 | 305 | 259 | 95 | 3601 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 4SB | 0 | 579 | 595 | 604 | 605 | 386 | 305 | 403 | 605 | 0 | 0 | 0 | 4082 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 5SB | 24 | 24 | 32 | 40 | 48 | 48 | 48 | 48 | 48 | 48 | 40 | 24 | 472 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 5SB | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 2160 |
| ZONE-7 ALAMEDA | CYOVMENT=WT077 | 6SB | 1375 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1375 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 6SB | 97 | 1417 | 1594 | 1346 | 1957 | 2199 | 2373 | 2333 | 1955 | 1615 | 1158 | 999 | 19043 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 6SB | 0 | 0 | 0 | 10 | 25 | 35 | 35 | 25 | 5 | 5 | 0 | 0 | 140 |
| *** TOTAL *** | | | 2920 | 2897 | 3268 | 3859 | 4881 | 5065 | 5234 | 5234 | 4797 | 4212 | 3433 | 2993 | 48793 |
| ALAMEDA CO WD | M GW ENT=WT008 | 7SB | 0 | 0 | 0 | 2554 | 2517 | 2495 | 2517 | 2517 | 2495 | 2455 | 32 | 0 | 17582 |
| ALAMEDA CO WD | M&I ENT=WT010 | 8SB | 2074 | 1873 | 2074 | 2007 | 2074 | 2007 | 2074 | 2074 | 2007 | 2074 | 2007 | 2074 | 24419 |
| *** TOTAL *** | | | 2074 | 1873 | 2074 | 4561 | 4591 | 4502 | 4591 | 4591 | 4502 | 4529 | 2039 | 2074 | 42001 |
| SANTA CLARA VWD | M&I ENT=WT010 | 9SB | 4400 | 4200 | 4400 | 5470 | 9200 | 9580 | 10460 | 10260 | 9600 | 8030 | 7100 | 5300 | 88000 |
| SANTA CLARA VWD | M GW ENT=WT008 | 9SB | 0 | 0 | 1000 | 2660 | 1260 | 1100 | 540 | 740 | 1000 | 2500 | 1200 | 0 | 12000 |
| *** TOTAL *** | | | 4400 | 4200 | 5400 | 8130 | 10460 | 10680 | 11000 | 11000 | 10600 | 10530 | 8300 | 5300 | 100000 |
| DUDLEY RIDGE WD | AGR ENT=WT001 | 8D | 2800 | 5800 | 3000 | 3400 | 5700 | 9600 | 10000 | 9800 | 2400 | 2200 | 1500 | 1500 | 57700 |
| *** TOTAL *** | | | 2800 | 5800 | 3000 | 3400 | 5700 | 9600 | 10000 | 9800 | 2400 | 2200 | 1500 | 1500 | 57700 |
| EMPIRE WS ID | AGR ENT=WT001 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | 12D AGR=WT013 | 8C | 390 | 160 | 320 | 60 | 0 | 320 | 460 | 460 | 330 | 80 | 260 | 160 | 3000 |
| *** TOTAL *** | | | 450 | 250 | 500 | 300 | 300 | 800 | 1000 | 1000 | 600 | 200 | 350 | 250 | 6000 |

FILE IDENTIFICATION: W199494

FILE DUMP

10/28/93.



| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KERN COUNTY WA | AGR ENT=WT001 | 9 | 1200 | 1200 | 5680 | 8800 | 9200 | 14750 | 21300 | 19900 | 5260 | 2840 | 3340 | 4500 | 97970 |
| KERN COUNTY WA | M&I ENT=WT010 | 10A | 100 | 100 | 100 | 150 | 150 | 150 | 150 | 150 | 150 | 100 | 100 | 100 | 1500 |
| KERN COUNTY WA | AGR ENT=WT001 | 10A | 3248 | 9947 | 13809 | 22095 | 29492 | 47535 | 54923 | 51075 | 11588 | 5309 | 3309 | 4198 | 256528 |
| KERN COUNTY WA | X82 ORO=WT051 | 10A | 0 | 8699 | 8307 | 0 | 0 | 0 | 0 | 0 | 3100 | 2000 | 1000 | 1000 | 24106 |
| KERN COUNTY WA | M&I ENT=WT010 | 11B | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1162 | 15000 |
| KERN COUNTY WA | AGR ENT=WT001 | 11B | 2660 | 5320 | 10640 | 10640 | 13300 | 21280 | 31920 | 26600 | 5320 | 2660 | 1330 | 1426 | 133096 |
| KERN COUNTY WA | M&I ENT=WT010 | 12E | 2110 | 1990 | 2300 | 2490 | 3010 | 3220 | 3500 | 3450 | 2920 | 2610 | 2000 | 2110 | 31710 |
| KERN COUNTY WA | M GW ENT=WT008 | 12E | 450 | 900 | 1600 | 500 | 6243 | 15028 | 15368 | 17206 | 5925 | 5940 | 6320 | 6410 | 81890 |
| KERN COUNTY WA | AGR ENT=WT001 | 12E | 2990 | 13490 | 9900 | 20076 | 30000 | 31200 | 30950 | 32100 | 25200 | 13640 | 13640 | 12170 | 235356 |
| KERN COUNTY WA | 12D AGR=WT013 | 12E | 15000 | 20000 | 22900 | 9000 | 0 | 0 | 0 | 0 | 4000 | 8000 | 8000 | 5000 | 91900 |
| KERN COUNTY WA | 78MWD 30=WT016 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2047 | 6500 | 6500 | 6500 | 21547 |
| KERN COUNTY WA | X82 ORO=WT051 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1239 | 5000 | 5000 | 5000 | 16239 |
| KERN COUNTY WA | X82 MWD=WT052 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 323 | 1000 | 1000 | 1000 | 3323 |
| KERN COUNTY WA | AGR ENT=WT001 | 13B | 0 | 0 | 2200 | 2200 | 3000 | 6700 | 10000 | 5500 | 0 | 0 | 2000 | 10150 | 41750 |
| KERN COUNTY WA | X82 ORO=WT051 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6048 | 6048 |
| KERN COUNTY WA | M&I ENT=WT010 | 14A | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 63 | 800 |
| KERN COUNTY WA | AGR ENT=WT001 | 14A | 300 | 1500 | 1000 | 1500 | 1800 | 3500 | 4500 | 4500 | 1000 | 300 | 200 | 800 | 20900 |
| KERN COUNTY WA | AGR ENT=WT001 | 14B | 1000 | 8500 | 2900 | 2400 | 4400 | 9800 | 12200 | 11400 | 3000 | 1400 | 1200 | 2400 | 60600 |
| KERN COUNTY WA | AGR ENT=WT001 | 14C | 500 | 6000 | 2000 | 1300 | 2300 | 4500 | 5600 | 4700 | 1500 | 700 | 500 | 1300 | 30900 |
| KERN COUNTY WA | AGR ENT=WT001 | 15A | 300 | 1500 | 700 | 3400 | 4800 | 7400 | 7700 | 4200 | 3700 | 2200 | 2200 | 2300 | 40400 |
| KERN COUNTY WA | M&I ENT=WT010 | 16A | 0 | 0 | 0 | 219 | 457 | 657 | 679 | 679 | 1001 | 8 | 0 | 0 | 3700 |
| KERN COUNTY WA | AGR ENT=WT001 | 16A | 200 | 1000 | 0 | 1519 | 2553 | 3657 | 3671 | 2779 | 1613 | 908 | 300 | 600 | 18800 |
| KERN COUNTY WA | AGR ENT=WT001 | 31A | 4000 | 4000 | 4000 | 6000 | 11000 | 15000 | 15000 | 9000 | 5500 | 4600 | 2600 | 1800 | 82500 |
| KERN COUNTY WA | 12D AGR=WT013 | 31A | 0 | 0 | 0 | 0 | 0 | 3100 | 5000 | 0 | 0 | 0 | 0 | 0 | 8100 |
| *** TOTAL *** | | | 35383 | 85471 | 89361 | 93614 | 123030 | 188802 | 223786 | 194564 | 85711 | 67040 | 61864 | 76037 | 1324663 |
| COUNTY OF KINGS | AGR ENT=WT001 | 8C | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 400 | 0 | 400 | 4000 |
| COUNTY OF KINGS | 12D AGR=WT013 | 8C | 400 | 400 | 400 | 400 | 100 | 400 | 400 | 400 | 400 | 400 | 100 | 400 | 4200 |
| *** TOTAL *** | | | 800 | 800 | 800 | 800 | 100 | 800 | 800 | 800 | 800 | 800 | 100 | 800 | 8200 |
| OAK FLAT WD | AGR ENT=WT001 | 2A | 64 | 171 | 342 | 456 | 627 | 1026 | 1026 | 1026 | 513 | 228 | 171 | 50 | 5700 |
| OAK FLAT WD | 12D AGR=WT013 | 2A | 250 | 250 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 500 |
| *** TOTAL *** | | | 314 | 421 | 342 | 456 | 627 | 1026 | 1026 | 1026 | 513 | 228 | 171 | 50 | 6200 |
| TULARE LK BWSD | AGR ENT=WT001 | 8C | 1240 | 2190 | 1030 | 1030 | 1060 | 8970 | 10710 | 9360 | 630 | 1360 | 3830 | 6000 | 47410 |
| TULARE LK BWSD | 12D AGR=WT013 | 8C | 1200 | 1536 | 1316 | 1096 | 1644 | 4060 | 4388 | 3292 | 988 | 768 | 1644 | 1768 | 23700 |
| TULARE LK BWSD | WETAWTHR=WT007 | 8C | 1644 | 2092 | 1792 | 1492 | 3240 | 5528 | 3026 | 4480 | 1344 | 1044 | 4190 | 2393 | 32265 |
| TULARE LK BWSD | AGR SUR=WT004 | 8C | 500 | 500 | 100 | 100 | 2000 | 0 | 0 | 400 | 200 | 300 | 300 | 1300 | 5700 |
| TULARE LK BWSD | AGR ENT=WT001 | 8D | 1860 | 3280 | 1550 | 1550 | 1590 | 13460 | 16060 | 14040 | 940 | 2040 | 5750 | 8970 | 71090 |
| TULARE LK BWSD | 12D AGR=WT013 | 8D | 1812 | 2304 | 1974 | 1644 | 2466 | 6090 | 6582 | 4938 | 1482 | 1152 | 2466 | 2640 | 35550 |
| TULARE LK BWSD | WETAWTHR=WT007 | 8D | 2466 | 3138 | 2688 | 2238 | 4860 | 8292 | 4539 | 6720 | 2016 | 1566 | 6285 | 3589 | 48397 |
| TULARE LK BWSD | AGR SUR=WT004 | 8D | 800 | 800 | 100 | 200 | 2900 | 0 | 0 | 700 | 300 | 400 | 700 | 1800 | 8700 |
| *** TOTAL *** | | | 11522 | 15840 | 10550 | 9350 | 19760 | 46400 | 45305 | 43930 | 7900 | 8630 | 25165 | 28460 | 272812 |
| AVEK WA | M&I ENT=WT010 | 18A | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 144 |
| AVEK WA | AGR ENT=WT001 | 19 | 5 | 5 | 27 | 42 | 65 | 90 | 105 | 120 | 117 | 65 | 51 | 21 | 713 |
| AVEK WA | M&I ENT=WT010 | 19C | 405 | 390 | 435 | 560 | 670 | 875 | 950 | 1005 | 785 | 545 | 560 | 430 | 7610 |
| AVEK WA | AGR ENT=WT001 | 19C | 11 | 141 | 576 | 968 | 1008 | 1376 | 1562 | 1202 | 971 | 635 | 181 | 26 | 8657 |
| AVEK WA | M&I ENT=WT010 | 20A | 1200 | 1450 | 1710 | 1950 | 2735 | 3425 | 4495 | 5265 | 3275 | 2775 | 2415 | 1560 | 32255 |
| AVEK WA | AGR ENT=WT001 | 20A | 0 | 0 | 9 | 12 | 16 | 20 | 20 | 20 | 15 | 10 | 8 | 8 | 138 |
| AVEK WA | M&I ENT=WT010 | 20B | 35 | 35 | 60 | 65 | 80 | 85 | 100 | 130 | 130 | 125 | 70 | 50 | 965 |
| AVEK WA | M&I ENT=WT010 | 22A | 185 | 150 | 330 | 290 | 355 | 550 | 620 | 700 | 485 | 455 | 395 | 285 | 4800 |

FILE DUMP

FILE IDENTIFICATION: W199494 10/28/93. SHEET 3

| AGENCY | WATER TYPE | | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AVEK WA | AGR | ENT=WT001 | 22A | 0 | 0 | 0 | 60 | 110 | 100 | 135 | 135 | 60 | 20 | 0 | 0 | 620 |
| *** TOTAL *** | | | | 1853 | 2183 | 3159 | 3959 | 5051 | 6533 | 7999 | 8589 | 5850 | 4642 | 3692 | 2392 | 55902 |
| CASTAIC LAKE WA | M&I | ENT=WT010 | 30 | 1524 | 1413 | 1865 | 1998 | 2279 | 2472 | 2633 | 2656 | 2555 | 2229 | 1649 | 1827 | 25100 |
| CASTAIC LAKE WA | AGR | ENT=WT001 | 31A | 254 | 381 | 762 | 1016 | 1270 | 2032 | 2286 | 2286 | 1143 | 508 | 381 | 381 | 12700 |
| CASTAIC LAKE WA | 12D | AGR=WT013 | 31A | 762 | 686 | 762 | 190 | 0 | 0 | 419 | 343 | 0 | 0 | 0 | 648 | 3810 |
| CASTAIC LAKE WA | AGR | SUR=WT004 | 31A | 698 | 628 | 698 | 175 | 0 | 0 | 384 | 314 | 0 | 0 | 0 | 593 | 3490 |
| *** TOTAL *** | | | | 3238 | 3108 | 4087 | 3379 | 3549 | 4504 | 5722 | 5599 | 3698 | 2737 | 2030 | 3449 | 45100 |
| COACHELLA VALLY | M&I | ENT=WT010 | 26A | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| *** TOTAL *** | | | | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| CRESTLINE-LA WA | M&I | ENT=WT010 | 24 | 150 | 165 | 152 | 96 | 128 | 138 | 206 | 215 | 197 | 170 | 171 | 162 | 1950 |
| *** TOTAL *** | | | | 150 | 165 | 152 | 96 | 128 | 138 | 206 | 215 | 197 | 170 | 171 | 162 | 1950 |
| DESERT WA | M GW | ENT=WT008 | 26A | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| *** TOTAL *** | | | | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| LITTLEROCK CR | M&I | ENT=WT010 | 21 | 60 | 60 | 130 | 150 | 200 | 240 | 280 | 280 | 240 | 150 | 80 | 60 | 1930 |
| LITTLEROCK CR | AGR | ENT=WT001 | 21 | 0 | 0 | 30 | 40 | 50 | 60 | 60 | 60 | 40 | 30 | 0 | 0 | 370 |
| *** TOTAL *** | | | | 60 | 60 | 160 | 190 | 250 | 300 | 340 | 340 | 280 | 180 | 80 | 60 | 2300 |
| METROPOLITAN WD | M&I | ENT=WT010 | 26A | 19780 | 9940 | 7580 | 26700 | 34660 | 33700 | 49540 | 49540 | 41500 | 33620 | 26500 | 21620 | 354680 |
| METROPOLITAN WD | M GW | ENT=WT008 | 26A | 22320 | 7560 | 22320 | 14400 | 7440 | 7200 | 11160 | 11160 | 10800 | 33480 | 32400 | 33480 | 213720 |
| METROPOLITAN WD | M&I | ENT=WT010 | 28H | 6000 | 6000 | 10000 | 11000 | 10000 | 10000 | 14100 | 14100 | 13700 | 10000 | 10000 | 10000 | 124900 |
| METROPOLITAN WD | BYPS | ENT=WT059 | 28H | 26200 | 23900 | 20000 | 22200 | 22200 | 25400 | 22500 | 22500 | 21700 | 22200 | 21000 | 22200 | 272000 |
| METROPOLITAN WD | M&I | ENT=WT010 | 28J | 400 | 400 | 400 | 400 | 400 | 5400 | 10400 | 10400 | 5400 | 400 | 400 | 400 | 34800 |
| METROPOLITAN WD | M&I | ENT=WT010 | 30 | 75300 | 86800 | 96800 | 93700 | 75300 | 77800 | 85300 | 80300 | 72800 | 96800 | 83700 | 86800 | 1011400 |
| *** TOTAL *** | | | | 150000 | 134600 | 157100 | 168400 | 150000 | 159500 | 193000 | 188000 | 165900 | 196500 | 174000 | 174500 | 2011500 |
| MOJAVE WA | M GW | ENT=WT008 | 24 | 4225 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4225 | 50800 |
| *** TOTAL *** | | | | 4225 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4225 | 50800 |
| PALMDALE WD | M&I | ENT=WT010 | 20B | 500 | 1000 | 1600 | 1600 | 1800 | 1800 | 1800 | 1800 | 1500 | 550 | 600 | 510 | 15060 |
| *** TOTAL *** | | | | 500 | 1000 | 1600 | 1600 | 1800 | 1800 | 1800 | 1800 | 1500 | 550 | 600 | 510 | 15060 |
| SAN BERNARDINO | M&I | ENT=WT010 | 26A | 0 | 0 | 0 | 1000 | 1000 | 1500 | 2000 | 2000 | 2000 | 1500 | 1000 | 0 | 12000 |
| SAN BERNARDINO | M GW | ENT=WT008 | 26A | 1000 | 1000 | 1000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 1000 | 1000 | 1000 | 18000 |
| *** TOTAL *** | | | | 1000 | 1000 | 1000 | 3000 | 3000 | 3500 | 4000 | 4000 | 4000 | 2500 | 2000 | 1000 | 30000 |
| SAN GABRIEL | M GW | ENT=WT008 | 26A | 0 | 0 | 0 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 0 | 16000 |
| *** TOTAL *** | | | | 0 | 0 | 0 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 0 | 16000 |
| VENTURA CO FCD | M GW | ENT=WT008 | 29H | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 2000 | 5000 |
| *** TOTAL *** | | | | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 2000 | 5000 |

100%



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COUNTY OF BUTTE TOTAL =      800
            TOT  ENT =      800  M&I  ENT =      800
--------------------------------
PLUMAS CO FCWCD TOTAL =     1250
            TOT  ENT =     1250  M&I  ENT =     1250
--------------------------------
YUBA CITY       TOTAL =     3450
            TOT  ENT =     3450  M&I  ENT =     3450
--------------------------------
NAPA CO FCWCD   TOTAL =     9780
            TOT  ENT =     9780  M&I  ENT =     9780
--------------------------------
SOLANO CO WA    TOTAL =    45640
            TOT  ENT =    34240  M&I  ENT =    17800  BEN ENT  =    13540  VAL ENT  =     2900
            TOT MISC =    11400  VAL PMT  =    11400
--------------------------------
ZONE-7 ALAMEDA  TOTAL =    49932
            TOT  ENT =    42000  M&I  ENT =    25605  M GW ENT =    11350  AGR  ENT =     5045
            TOT MISC =     7932  GEN WLNG =      667  LOCAL    =     7265
--------------------------------
ALAMEDA CO WD   TOTAL =    42000
            TOT  ENT =    42000  M&I  ENT =    22624  M GW ENT =    19376
--------------------------------
SANTA CLARA VWD TOTAL =   100000
            TOT  ENT =   100000  M&I  ENT =    88000  M GW ENT =    12000
--------------------------------
DUDLEY RIDGE WD TOTAL =    59800
            TOT  ENT =    59800  AGR  ENT =    57700  CYOV ENT =     2100
--------------------------------
EMPIRE WS ID    TOTAL =     6430
            TOT  ENT =     6430  AGR  ENT =     3000  12D  AGR =     2560  CYOV ENT =      870
--------------------------------
KERN COUNTY WA  TOTAL =  1247400
            TOT  ENT =  1247400  M&I  ENT =    52910  M GW ENT =    81690  AGR  ENT =  1018800  12D  AGR =    94000
--------------------------------
COUNTY OF KINGS TOTAL =     8000
            TOT  ENT =     8000  AGR  ENT =     4000  12D  AGR =     4000
--------------------------------
OAK FLAT WD     TOTAL =     5700
            TOT  ENT =     5700  AGR  ENT =     5700
--------------------------------
TULARE LK BWSD  TOTAL =   300812
            TOT  ENT =   258412  AGR  ENT =   118500  12D  AGR =    59250  WETAWTHR =    80662
            TOT  SUR =    42400  AGR  SUR =    42400
--------------------------------
AVEK WA         TOTAL =   138390
            TOT  ENT =   138390  M&I  ENT =   126590  AGR  ENT =    11800
```

STATE OF CALIFORNIA
THE RESOURCES AGENCY

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1995

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

FILE ID: V199595

DATE: 02/06/95
PAGE: 2

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-------------------------------
CASTAIC LAKE WA TOTAL =   47998
          TOT  ENT =   44508  M&I  ENT =   27998  AGR  ENT =   12700  12D  AGR =    3810
          TOT  SUR =    3490  AGR  SUR =    3490
-------------------------------
COACHELLA VALLY TOTAL =   23100
          TOT  ENT =   23100  M&I  ENT =   23100
-------------------------------
CRESTLINE-LA WA TOTAL =    1950
          TOT  ENT =    1950  M&I  ENT =    1950
-------------------------------
DESERT WA       TOTAL =   38100
          TOT  ENT =   38100  M GW ENT =   38100
-------------------------------
LITTLEROCK CR   TOTAL =    2300
          TOT  ENT =    2300  M&I  ENT =    1930  AGR  ENT =     370
-------------------------------
METROPOLITAN WD TOTAL = 2011500
          TOT  ENT = 2011500  M&I  ENT = 1525780  M GW ENT =  213720  BYPS ENT =  272000
-------------------------------
MOJAVE WA       TOTAL =   50800
          TOT  ENT =   50800  M GW ENT =   50800
-------------------------------
PALMDALE WD     TOTAL =   15560
          TOT  ENT =   15560  M&I  ENT =   15560
-------------------------------
SAN BERNARDINO  TOTAL =   54000
          TOT  ENT =   54000  M&I  ENT =   34000  M GW ENT =   20000
-------------------------------
SAN GABRIEL     TOTAL =   10000
          TOT  ENT =   10000  M GW ENT =   10000
-------------------------------
VENTURA CO FCD  TOTAL =   20000
          TOT  ENT =   20000  M&I  ENT =   15000  M GW ENT =    5000
-------------------------------
JG BOSWELL      TOTAL =   14170
          TOT MISC =   14170  REPAYMNT =   14170
-------------------------------
FISH & GAME     TOTAL =    1200
          TOT MISC =    1200  REC/F&WL =    1200
-------------------------------
PARKS & RECREAT TOTAL =     189
          TOT MISC =     189  REC/F&WL =     189
-------------------------------
REC/FISH&WILDLF TOTAL =    7460
          TOT MISC =    7460  REC/F&WL =    7460
-------------------------------
FRESNO COUNTY   TOTAL =    3000
          TOT MISC =    3000  CVC WLNG =    3000
```

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT010 | FR | 35 | 45 | 110 | 310 | 64 | 64 | 24 | 24 | 24 | 24 | 34 | 42 | 800 |
| *** TOTAL *** | | | 35 | 45 | 110 | 310 | 64 | 64 | 24 | 24 | 24 | 24 | 34 | 42 | 800 |
| PLUMAS CO FCWCD | M&I ENT=WT010 | FR | 45 | 50 | 60 | 125 | 140 | 150 | 150 | 150 | 150 | 100 | 65 | 65 | 1250 |
| *** TOTAL *** | | | 45 | 50 | 60 | 125 | 140 | 150 | 150 | 150 | 150 | 100 | 65 | 65 | 1250 |
| YUBA CITY | M&I ENT=WT010 | FR | 0 | 0 | 0 | 0 | 0 | 500 | 1000 | 1000 | 500 | 450 | 0 | 0 | 3450 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 500 | 1000 | 1000 | 500 | 450 | 0 | 0 | 3450 |
| NAPA CO FCWCD | M&I ENT=WT010 | 3NB | 699 | 494 | 556 | 773 | 958 | 1031 | 1031 | 1031 | 944 | 790 | 730 | 743 | 9780 |
| *** TOTAL *** | | | 699 | 494 | 556 | 773 | 958 | 1031 | 1031 | 1031 | 944 | 790 | 730 | 743 | 9780 |
| SOLANO CO WA | M&I ENT=WT010 | 1NB | 450 | 450 | 475 | 1525 | 1950 | 1950 | 1950 | 1950 | 1950 | 1950 | 1650 | 1550 | 17800 |
| SOLANO CO WA | VAL PMT =WT071 | 1NB | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 100 |
| SOLANO CO WA | BEN ENT =WT046 | 3NA | 845 | 950 | 990 | 1140 | 1235 | 1235 | 1310 | 1300 | 1235 | 1205 | 1205 | 890 | 13540 |
| SOLANO CO WA | VAL ENT =WT047 | 3NA | 0 | 0 | 0 | 0 | 0 | 500 | 500 | 500 | 500 | 500 | 400 | 0 | 2900 |
| SOLANO CO WA | VAL PMT =WT071 | 3NA | 900 | 900 | 900 | 900 | 1000 | 1000 | 1000 | 1000 | 1000 | 900 | 900 | 900 | 11300 |
| *** TOTAL *** | | | 2195 | 2300 | 2365 | 3565 | 4185 | 4710 | 4785 | 4775 | 4710 | 4555 | 4155 | 3340 | 45640 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 1SB | 3 | 2 | 10 | 20 | 34 | 41 | 44 | 46 | 39 | 28 | 9 | 4 | 280 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 2SB | 488 | 474 | 545 | 698 | 1077 | 1140 | 1140 | 1140 | 1093 | 861 | 610 | 510 | 9776 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 4SB | 200 | 49 | 230 | 1040 | 1140 | 1130 | 1170 | 1170 | 1170 | 1170 | 1130 | 871 | 10470 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 4SB | 114 | 135 | 338 | 438 | 568 | 602 | 643 | 580 | 409 | 310 | 231 | 97 | 4465 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 4SB | 430 | 371 | 480 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 99 | 1380 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 5SB | 0 | 0 | 0 | 0 | 0 | 80 | 180 | 180 | 180 | 180 | 80 | 0 | 880 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 5SB | 12 | 12 | 22 | 52 | 52 | 52 | 52 | 52 | 46 | 51 | 45 | 12 | 460 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 5SB | 180 | 180 | 180 | 180 | 180 | 100 | 0 | 0 | 0 | 0 | 100 | 180 | 1280 |
| ZONE-7 ALAMEDA | GEN WLNG=WT079 | 6SB | 0 | 0 | 71 | 90 | 112 | 115 | 122 | 102 | 44 | 11 | 0 | 0 | 667 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 6SB | 0 | 0 | 0 | 686 | 2021 | 2433 | 2652 | 2684 | 2141 | 1711 | 1221 | 0 | 15549 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 6SB | 0 | 0 | 0 | 5 | 15 | 35 | 35 | 25 | 5 | 0 | 0 | 0 | 120 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 6SB | 977 | 948 | 1019 | 620 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 1021 | 4605 |
| *** TOTAL *** | | | 2404 | 2171 | 2895 | 3829 | 5219 | 5728 | 6038 | 5979 | 5127 | 4322 | 3426 | 2794 | 49932 |
| ALAMEDA CO WD | M GW ENT=WT008 | 7SB | 1228 | 1109 | 1228 | 1782 | 1841 | 2079 | 2148 | 2148 | 2079 | 1841 | 972 | 921 | 19376 |
| ALAMEDA CO WD | M&I ENT=WT010 | 8SB | 1332 | 1203 | 1691 | 2007 | 2074 | 2007 | 2074 | 2074 | 2007 | 2074 | 2007 | 2074 | 22624 |
| *** TOTAL *** | | | 2560 | 2312 | 2919 | 3789 | 3915 | 4086 | 4222 | 4222 | 4086 | 3915 | 2979 | 2995 | 42000 |
| SANTA CLARA VWD | M&I ENT=WT010 | 9SB | 4400 | 4200 | 4400 | 5470 | 9200 | 9580 | 10460 | 10260 | 9600 | 8030 | 7100 | 5300 | 88000 |
| SANTA CLARA VWD | M GW ENT=WT008 | 9SB | 0 | 0 | 1000 | 2660 | 1260 | 1100 | 540 | 740 | 1000 | 2500 | 1200 | 0 | 12000 |
| *** TOTAL *** | | | 4400 | 4200 | 5400 | 8130 | 10460 | 10680 | 11000 | 11000 | 10600 | 10530 | 8300 | 5300 | 100000 |
| SAN LUIS OBISPO | M&I ENT=WT010 | 33A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SAN LUIS OBISPO | M&I ENT=WT010 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| DUDLEY RIDGE WD | AGR ENT=WT001 | 8D | 1690 | 6350 | 1960 | 1520 | 2760 | 11700 | 11980 | 11700 | 2860 | 2000 | 1240 | 1940 | 57700 |
| DUDLEY RIDGE WD | CYOV ENT=WT069 | 8D | 310 | 850 | 940 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2100 |

FILE DUMP

FILE IDENTIFICATION: V199595 02/06/95. SHEET 2

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *** TOTAL *** | | | 2000 | 7200 | 2900 | 1520 | 2760 | 11700 | 11980 | 11700 | 2860 | 2000 | 1240 | 1940 | 59800 |
| EMPIRE WS ID | AGR ENT=WT001 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | 12D AGR=WT013 | 8C | 0 | 0 | 360 | 0 | 0 | 400 | 400 | 400 | 300 | 100 | 300 | 300 | 2560 |
| EMPIRE WS ID | CYOV ENT=WT069 | 8C | 400 | 470 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 870 |
| *** TOTAL *** | | | 460 | 560 | 540 | 240 | 300 | 880 | 940 | 940 | 570 | 220 | 390 | 390 | 6430 |
| KERN COUNTY WA | AGR ENT=WT001 | 9 | 1200 | 1200 | 5680 | 8800 | 9200 | 14750 | 21300 | 19900 | 5260 | 2840 | 3340 | 4500 | 97970 |
| KERN COUNTY WA | M&I ENT=WT010 | 10A | 100 | 100 | 100 | 150 | 150 | 150 | 150 | 150 | 150 | 100 | 100 | 100 | 1500 |
| KERN COUNTY WA | AGR ENT=WT001 | 10A | 3248 | 9947 | 13609 | 22095 | 29592 | 47735 | 55473 | 50575 | 11038 | 5309 | 3309 | 4198 | 256128 |
| KERN COUNTY WA | M&I ENT=WT010 | 11B | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1258 | 1162 | 15000 |
| KERN COUNTY WA | AGR ENT=WT001 | 11B | 2660 | 5320 | 10640 | 10640 | 13300 | 21280 | 31920 | 26600 | 5320 | 2660 | 1330 | 1426 | 133096 |
| KERN COUNTY WA | M&I ENT=WT010 | 12E | 2110 | 1990 | 2300 | 2490 | 3010 | 3220 | 3500 | 3450 | 2920 | 2610 | 2000 | 2110 | 31710 |
| KERN COUNTY WA | M GW ENT=WT008 | 12E | 250 | 300 | 500 | 500 | 3200 | 9185 | 9025 | 10635 | 5225 | 5940 | 6320 | 6410 | 57490 |
| KERN COUNTY WA | AGR ENT=WT001 | 12E | 1320 | 11420 | 10220 | 17921 | 24920 | 32525 | 34425 | 27120 | 20120 | 15920 | 14220 | 12625 | 222756 |
| KERN COUNTY WA | 12D AGR=WT013 | 12E | 15000 | 15000 | 21900 | 9000 | 0 | 0 | 0 | 0 | 4000 | 8000 | 8000 | 5000 | 85900 |
| KERN COUNTY WA | M GW ENT=WT008 | 13B | 0 | 1000 | 0 | 0 | 2000 | 8000 | 8000 | 4000 | 1200 | 0 | 0 | 0 | 24200 |
| KERN COUNTY WA | AGR ENT=WT001 | 13B | 0 | 0 | 1750 | 2200 | 3500 | 10700 | 13500 | 8000 | 0 | 0 | 2000 | 9600 | 51250 |
| KERN COUNTY WA | M&I ENT=WT010 | 14A | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 63 | 800 |
| KERN COUNTY WA | AGR ENT=WT001 | 14A | 200 | 700 | 2100 | 2000 | 1000 | 4100 | 6000 | 4400 | 700 | 400 | 100 | 600 | 22300 |
| KERN COUNTY WA | AGR ENT=WT001 | 14B | 2300 | 4600 | 8200 | 4500 | 3600 | 12000 | 14600 | 12900 | 3400 | 2000 | 1500 | 2800 | 72400 |
| KERN COUNTY WA | AGR ENT=WT001 | 14C | 700 | 1300 | 1800 | 2400 | 2500 | 5200 | 6200 | 5700 | 1700 | 800 | 1100 | 1700 | 31100 |
| KERN COUNTY WA | M&I ENT=WT010 | 15A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | AGR ENT=WT001 | 15A | 600 | 1200 | 1700 | 3000 | 800 | 5500 | 6300 | 3600 | 2100 | 3100 | 500 | 1000 | 29400 |
| KERN COUNTY WA | M&I ENT=WT010 | 16A | 0 | 0 | 0 | 219 | 457 | 657 | 679 | 679 | 1001 | 208 | 0 | 0 | 3900 |
| KERN COUNTY WA | AGR ENT=WT001 | 16A | 300 | 100 | 300 | 819 | 1653 | 2857 | 3479 | 1979 | 813 | 700 | 100 | 300 | 13400 |
| KERN COUNTY WA | AGR ENT=WT001 | 31A | 5000 | 4000 | 4000 | 7000 | 11000 | 16300 | 17000 | 9000 | 5500 | 4600 | 2600 | 3000 | 89000 |
| KERN COUNTY WA | 12D AGR=WT013 | 31A | 0 | 0 | 0 | 0 | 0 | 3100 | 5000 | 0 | 0 | 0 | 0 | 0 | 8100 |
| *** TOTAL *** | | | 36313 | 59502 | 86124 | 95059 | 111207 | 198584 | 237876 | 190013 | 71772 | 56512 | 47844 | 56594 | 1247400 |
| COUNTY OF KINGS | AGR ENT=WT001 | 8C | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 4000 |
| COUNTY OF KINGS | 12D AGR=WT013 | 8C | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 4000 |
| *** TOTAL *** | | | 800 | 800 | 800 | 400 | 400 | 800 | 800 | 800 | 400 | 400 | 800 | 800 | 8000 |
| OAK FLAT WD | AGR ENT=WT001 | 2A | 114 | 171 | 342 | 456 | 570 | 912 | 1026 | 1026 | 513 | 228 | 171 | 171 | 5700 |
| *** TOTAL *** | | | 114 | 171 | 342 | 456 | 570 | 912 | 1026 | 1026 | 513 | 228 | 171 | 171 | 5700 |
| TULARE LK BWSD | AGR ENT=WT001 | 8C | 320 | 320 | 600 | 1920 | 1240 | 9200 | 10440 | 9800 | 80 | 80 | 6680 | 6720 | 47400 |
| TULARE LK BWSD | 12D AGR=WT013 | 8C | 160 | 160 | 300 | 960 | 620 | 4600 | 4121 | 4481 | 1139 | 459 | 3340 | 3360 | 23700 |
| TULARE LK BWSD | WETAWTHR=WT007 | 8C | 4320 | 3520 | 4440 | 3520 | 3200 | 600 | 200 | 840 | 1960 | 4000 | 840 | 4825 | 32265 |
| TULARE LK BWSD | AGR SUR=WT004 | 8C | 0 | 0 | 0 | 280 | 40 | 3720 | 4280 | 3920 | 0 | 0 | 2640 | 2080 | 16960 |
| TULARE LK BWSD | AGR ENT=WT001 | 8D | 480 | 480 | 900 | 2880 | 1860 | 13800 | 15660 | 14700 | 120 | 120 | 10020 | 10080 | 71100 |
| TULARE LK BWSD | 12D AGR=WT013 | 8D | 240 | 240 | 450 | 1440 | 930 | 6900 | 6182 | 6722 | 1708 | 688 | 5010 | 5040 | 35550 |
| TULARE LK BWSD | WETAWTHR=WT007 | 8D | 6480 | 5280 | 6660 | 5280 | 4800 | 900 | 300 | 1260 | 2940 | 6000 | 1260 | 7237 | 48397 |
| TULARE LK BWSD | AGR SUR=WT004 | 8D | 0 | 0 | 0 | 420 | 60 | 5580 | 6420 | 5880 | 0 | 0 | 3960 | 3120 | 25440 |
| *** TOTAL *** | | | 12000 | 10000 | 13350 | 16700 | 12750 | 45300 | 47603 | 47603 | 7947 | 11347 | 33750 | 42462 | 300812 |
| AVEK WA | M&I ENT=WT010 | 18A | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 144 |
| AVEK WA | AGR ENT=WT001 | 19C | 12 | 142 | 779 | 1371 | 1209 | 1480 | 2065 | 1405 | 973 | 635 | 181 | 26 | 10278 |
| AVEK WA | M&I ENT=WT010 | 20A | 950 | 925 | 1700 | 2750 | 3130 | 3200 | 4500 | 3720 | 3640 | 3650 | 2300 | 1000 | 31465 |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *** TOTAL *** | | | | 12000 | 10000 | 13350 | 16700 | 12750 | 45300 | 47603 | 47603 | 7947 | 11347 | 33750 | 42462 | 300812 |
| AVEK WA | M&I | ENT=WT010 | 18A | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 144 |
| AVEK AGENCY | WATER TYPE | | RCH | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
| AVEK WA | AGR | ENT=WT001 | 19C | 12 | 142 | 779 | 1971 | 1209 | 1480 | 2065 | 1405 | 973 | 635 | 181 | 26 | 10278 |
| AVEK WA | M&I | ENT=WT010 | 20A | 950 | 925 | 1700 | 2750 | 3130 | 3200 | 4500 | 3720 | 3640 | 3650 | 2300 | 1000 | 31465 |
| AVEK WA | AGR | ENT=WT001 | 20A | 8 | 8 | 9 | 12 | 16 | 20 | 20 | 20 | 15 | 10 | 8 | 8 | 154 |
| AVEK WA | M&I | ENT=WT010 | 20B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AVEK WA | M&I | ENT=WT010 | 22A | 90 | 90 | 200 | 435 | 450 | 465 | 670 | 480 | 450 | 450 | 240 | 120 | 4140 |
| AVEK WA | AGR | ENT=WT001 | 22A | 5 | 5 | 10 | 60 | 110 | 100 | 135 | 135 | 60 | 20 | 10 | 5 | 655 |
| *** TOTAL *** | | | | 11600 | 11600 | 11600 | 11500 | 11500 | 11500 | 11500 | 11500 | 11500 | 11500 | 11490 | 11600 | 138390 |
| CASTAIC LAKE WA | M&I | ENT=WT010 | 30 | 1700 | 1576 | 2080 | 2229 | 2542 | 2758 | 2937 | 2962 | 2850 | 2486 | 1840 | 2038 | 27998 |
| CASTAIC LAKE WA | AGR | ENT=WT001 | 31A | 254 | 381 | 762 | 1016 | 1270 | 2032 | 2286 | 2286 | 1143 | 508 | 381 | 381 | 12700 |
| CASTAIC LAKE WA | 12D | AGR=WT013 | 31A | 762 | 686 | 762 | 190 | 0 | 0 | 419 | 343 | 0 | 0 | 0 | 648 | 3810 |
| CASTAIC LAKE WA | AGR | SUR=WT004 | 31A | 698 | 628 | 698 | 175 | 0 | 0 | 384 | 314 | 0 | 0 | 0 | 593 | 3490 |
| *** TOTAL *** | | | | 3414 | 3271 | 4302 | 3610 | 3812 | 4790 | 6026 | 5905 | 3993 | 2994 | 2221 | 3660 | 47998 |
| COACHELLA VALLY | M&I | ENT=WT010 | 26A | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| *** TOTAL *** | | | | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| CRESTLINE-LA WA | M&I | ENT=WT010 | 24 | 150 | 165 | 152 | 96 | 128 | 138 | 206 | 215 | 197 | 170 | 171 | 162 | 1950 |
| *** TOTAL *** | | | | 150 | 165 | 152 | 96 | 128 | 138 | 206 | 215 | 197 | 170 | 171 | 162 | 1950 |
| DESERT WA | M GW | ENT=WT008 | 26A | 6505 | 5876 | 6505 | 6296 | 6505 | 6296 | 117 | 0 | 0 | 0 | 0 | 0 | 38100 |
| *** TOTAL *** | | | | 6505 | 5876 | 6505 | 6296 | 6505 | 6296 | 117 | 0 | 0 | 0 | 0 | 0 | 38100 |
| LITTLEROCK CR | M&I | ENT=WT010 | 21 | 60 | 60 | 130 | 150 | 200 | 240 | 280 | 280 | 240 | 150 | 80 | 60 | 1930 |
| LITTLEROCK CR | AGR | ENT=WT001 | 21 | 0 | 0 | 30 | 40 | 50 | 60 | 60 | 60 | 40 | 30 | 0 | 0 | 370 |
| *** TOTAL *** | | | | 60 | 60 | 160 | 190 | 250 | 300 | 340 | 340 | 280 | 180 | 80 | 60 | 2300 |
| METROPOLITAN WD | M&I | ENT=WT010 | 26A | 16450 | 7239 | 4250 | 23370 | 31539 | 30579 | 52598 | 52715 | 44675 | 36795 | 29675 | 24795 | 354680 |
| METROPOLITAN WD | M GW | ENT=WT008 | 26A | 22320 | 7560 | 22320 | 14400 | 7440 | 7200 | 11160 | 11160 | 10800 | 33480 | 32400 | 33480 | 213720 |
| METROPOLITAN WD | M&I | ENT=WT010 | 28H | 6000 | 6000 | 10000 | 11000 | 10000 | 10000 | 14100 | 14100 | 13700 | 10000 | 10000 | 10000 | 124900 |
| METROPOLITAN WD | BYPS | ENT=WT059 | 28H | 26200 | 23900 | 20000 | 22200 | 22200 | 25400 | 22500 | 22500 | 21700 | 22200 | 21000 | 22200 | 272000 |
| METROPOLITAN WD | M&I | ENT=WT010 | 28J | 400 | 400 | 400 | 400 | 400 | 5400 | 10400 | 10400 | 5400 | 400 | 400 | 400 | 34800 |
| METROPOLITAN WD | M&I | ENT=WT010 | 30 | 75300 | 86800 | 96800 | 93700 | 75300 | 77800 | 85300 | 80300 | 72800 | 96800 | 83700 | 86800 | 1011400 |
| *** TOTAL *** | | | | 146670 | 131899 | 153770 | 165070 | 146879 | 156379 | 196058 | 191175 | 169075 | 199675 | 177175 | 177675 | 2011500 |
| MOJAVE WA | M GW | ENT=WT008 | 24 | 4225 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4225 | 50800 |
| *** TOTAL *** | | | | 4225 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4235 | 4225 | 50800 |
| PALMDALE WD | M&I | ENT=WT010 | 20B | 500 | 700 | 1500 | 1800 | 1800 | 1850 | 2000 | 2000 | 1500 | 600 | 800 | 510 | 15560 |
| *** TOTAL *** | | | | 500 | 700 | 1500 | 1800 | 1800 | 1850 | 2000 | 2000 | 1500 | 600 | 800 | 510 | 15560 |
| SAN BERNARDINO | M&I | ENT=WT010 | 26A | 1000 | 1000 | 1000 | 2000 | 3000 | 4000 | 4000 | 5000 | 5000 | 4000 | 3000 | 1000 | 34000 |
| SAN BERNARDINO | M GW | ENT=WT008 | 26A | 1000 | 1000 | 1000 | 2000 | 2000 | 3000 | 3000 | 2000 | 2000 | 1000 | 1000 | 1000 | 20000 |
| *** TOTAL *** | | | | 2000 | 2000 | 2000 | 4000 | 5000 | 7000 | 7000 | 7000 | 7000 | 5000 | 4000 | 2000 | 54000 |
| SAN GABRIEL | M GW | ENT=WT008 | 26A | 0 | 0 | 0 | 0 | 1800 | 1800 | 1800 | 1800 | 1800 | 1000 | 0 | 0 | 10000 |

FILE ID: U199696

DATE: 08/26/96
PAGE: 1

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COUNTY OF BUTTE TOTAL =      800
            TOT  ENT =      800  M&I  ENT =      800
PLUMAS CO FCWCD TOTAL =     1300
            TOT  ENT =     1300  M&I  ENT =     1300
YUBA CITY       TOTAL =     3150
            TOT  ENT =     3150  M&I  ENT =     3150
NAPA CO FCWCD   TOTAL =    10425
            TOT  ENT =    10425  M&I  ENT =    10425
SOLANO CO WA    TOTAL =    48810
            TOT  ENT =    37800  M&I  ENT =    19770  BEN ENT =    13540  EXMCOENT =     4490
            TOT MISC =    11010  VAL PMT =    11010
ZONE-7 ALAMEDA  TOTAL =    51667
            TOT  ENT =    44000  M&I  ENT =    20461  M GW ENT =     5750  AGR  ENT =     5789  EXMCOENT =    12000
            TOT MISC =     7667  GEN WLNG =      667  LOCAL      =     7000
ALAMEDA CO WD   TOTAL =    42000
            TOT  ENT =    42000  M&I  ENT =    25432  M GW ENT =     3468  STOR ENT =     1000  EXMCOENT =    12100
SANTA CLARA VWD TOTAL =   100000
            TOT  ENT =   100000  M&I  ENT =    74800  M GW ENT =    10200  EXMCOENT =    15000
SAN LUIS OBISPO TOTAL =    25000
            TOT  ENT =      788  M&I  ENT =      788
            TOT MISC =    24212  PURPOOLA =    24212
SANTA BARBARA   TOTAL =    42986
            TOT  ENT =     3851  M&I  ENT =     3851
            TOT MISC =    39135  PURPOOLA =    39135
DUDLEY RIDGE WD TOTAL =    53370
            TOT  ENT =    53370  AGR  ENT =    43370  A GW ENT =    10000
EMPIRE WS ID    TOTAL =     5998
            TOT  ENT =     5998  AGR  ENT =     3000  WETAWTHR =     2998
KERN COUNTY WA  TOTAL =  1271123
            TOT  ENT =  1199860  M&I  ENT =    37510  M GW ENT =    82190  AGR  ENT =   874360  EXACOENT =   121300  EXMCOENT =     1700
                                 CARY OVR =    82800
            TOT MISC =    71263  78MWD 30 =    21547  X82  ORO =    46393  X82  MWD =     3323
COUNTY OF KINGS TOTAL =     4000
            TOT  ENT =     4000  AGR  ENT =     4000
```

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| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OAK FLAT WD | TOTAL = | 5700 | | | | | | | | | |
| | TOT ENT = | 5700 | AGR ENT = | 5700 | | | | | | | |
| TULARE LK BWSD | TOTAL = | 168500 | | | | | | | | | |
| | TOT ENT = | 168500 | AGR ENT = | 113500 | EXACOENT = | 5000 | CYOV ENT = | 50000 | | | |
| AVEK WA | TOTAL = | 140085 | | | | | | | | | |
| | TOT ENT = | 56822 | M&I ENT = | 44548 | AGR ENT = | 12274 | | | | | |
| | TOT MISC = | 83263 | TRANSFER = | 1685 | PURPOOLA = | 81578 | | | | | |
| CASTAIC LAKE WA | TOTAL = | 39800 | | | | | | | | | |
| | TOT ENT = | 39800 | M&I ENT = | 27100 | AGR ENT = | 12700 | | | | | |
| COACHELLA VALLY | TOTAL = | 23100 | | | | | | | | | |
| | TOT ENT = | 23100 | M&I ENT = | 23100 | | | | | | | |
| CRESTLINE-LA WA | TOTAL = | 4150 | | | | | | | | | |
| | TOT ENT = | 4150 | M&I ENT = | 1950 | STOR ENT = | 2200 | | | | | |
| DESERT WA | TOTAL = | 38100 | | | | | | | | | |
| | TOT ENT = | 38100 | EXCHMENT = | 38100 | | | | | | | |
| LITTLEROCK CR | TOTAL = | 2300 | | | | | | | | | |
| | TOT ENT = | 2300 | M&I ENT = | 1930 | AGR ENT = | 370 | | | | | |
| METROPOLITAN WD | TOTAL = | 738800 | | | | | | | | | |
| | TOT ENT = | 738800 | M&I ENT = | 492800 | BYPS ENT = | 71000 | STOR ENT = | 75000 | EXMCOENT = | 100000 | |
| | TOT MISC = | 0 | 78 EX GW = | -21547 | X82 GW = | 3323 | -78EX GW = | -21547 | -X82 GW = | -3323 | |
| MOJAVE WA | TOTAL = | 20000 | | | | | | | | | |
| | TOT ENT = | 20000 | TRANMENT = | 1382 | M GW ENT = | 18618 | | | | | |
| PALMDALE WD | TOTAL = | 17300 | | | | | | | | | |
| | TOT ENT = | 17300 | TRANMENT = | 303 | M&I ENT = | 16997 | | | | | |
| SAN BERNARDINO | TOTAL = | 27000 | | | | | | | | | |
| | TOT ENT = | 27000 | M&I ENT = | 17000 | M GW ENT = | 10000 | | | | | |
| SAN GABRIEL | TOTAL = | 16000 | | | | | | | | | |
| | TOT ENT = | 16000 | M GW ENT = | 16000 | | | | | | | |
| VENTURA CO FCD | TOTAL = | 10000 | | | | | | | | | |
| | TOT ENT = | 10000 | M&I ENT = | 5000 | M GW ENT = | 5000 | | | | | |
| FISH & GAME | TOTAL = | 1200 | | | | | | | | | |
| | TOT MISC = | 1200 | REC/F&WL = | 1200 | | | | | | | |
| PARKS & RECREAT | TOTAL = | 189 | | | | | | | | | |
| | TOT MISC = | 189 | REC/F&WL = | 189 | | | | | | | |

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT010 | FR | 35 | 45 | 110 | 310 | 64 | 64 | 24 | 24 | 24 | 24 | 34 | 42 | 800 |
| *** TOTAL *** | | | 35 | 45 | 110 | 310 | 64 | 64 | 24 | 24 | 24 | 24 | 34 | 42 | 800 |
| PLUMAS CO FCWCD | M&I ENT=WT010 | FR | 50 | 60 | 60 | 125 | 150 | 150 | 150 | 150 | 150 | 125 | 65 | 65 | 1300 |
| *** TOTAL *** | | | 50 | 60 | 60 | 125 | 150 | 150 | 150 | 150 | 150 | 125 | 65 | 65 | 1300 |
| YUBA CITY | M&I ENT=WT010 | FR | 0 | 0 | 0 | 0 | 0 | 500 | 1000 | 1000 | 500 | 150 | 0 | 0 | 3150 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 500 | 1000 | 1000 | 500 | 150 | 0 | 0 | 3150 |
| NAPA CO FCWCD | M&I ENT=WT010 | 3NB | 735 | 531 | 596 | 822 | 1006 | 1083 | 1083 | 1083 | 1019 | 862 | 797 | 808 | 10425 |
| *** TOTAL *** | | | 735 | 531 | 596 | 822 | 1006 | 1083 | 1083 | 1083 | 1019 | 862 | 797 | 808 | 10425 |
| SOLANO CO WA | M&I ENT=WT010 | 1NB | 335 | 350 | 375 | 2020 | 2170 | 2170 | 2270 | 2270 | 2170 | 2070 | 2020 | 1550 | 19770 |
| SOLANO CO WA | VAL PMT =WT071 | 1NB | 55 | 40 | 50 | 80 | 30 | 250 | 140 | 120 | 160 | 150 | 40 | 45 | 1160 |
| SOLANO CO WA | BEN ENT =WT046 | 3NA | 845 | 950 | 990 | 1140 | 1235 | 1235 | 1310 | 1300 | 1235 | 1205 | 1205 | 890 | 13540 |
| SOLANO CO WA | VAL ENT =WT047 | 3NA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SOLANO CO WA | VAL PMT =WT071 | 3NA | 500 | 550 | 600 | 750 | 950 | 1000 | 1150 | 1150 | 1100 | 1000 | 550 | 550 | 9850 |
| SOLANO CO WA | EXMCOENT=WT116 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4490 | 4490 |
| *** TOTAL *** | | | 1735 | 1890 | 2015 | 3990 | 4385 | 4655 | 4870 | 4840 | 4665 | 4425 | 3815 | 7525 | 48810 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 1SB | 11 | 14 | 16 | 68 | 94 | 108 | 81 | 83 | 79 | 59 | 16 | 7 | 636 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 2SB | 343 | 337 | 369 | 568 | 967 | 967 | 967 | 967 | 967 | 828 | 579 | 485 | 8344 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 2SB | 121 | 101 | 129 | 94 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 445 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 4SB | 346 | 314 | 346 | 456 | 477 | 460 | 477 | 477 | 477 | 350 | 338 | 356 | 4874 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 4SB | 34 | 105 | 124 | 226 | 461 | 478 | 498 | 470 | 178 | 201 | 97 | 29 | 2901 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 5SB | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 876 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 5SB | 10 | 10 | 20 | 60 | 70 | 80 | 80 | 80 | 40 | 30 | 10 | 10 | 500 |
| ZONE-7 ALAMEDA | GEN WLNG=WT079 | 6SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 667 | 0 | 0 | 0 | 667 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 6SB | 0 | 0 | 0 | 0 | 1323 | 1730 | 1992 | 2404 | 1613 | 1657 | 964 | 434 | 12117 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 6SB | 15 | 63 | 94 | 164 | 230 | 270 | 300 | 250 | 179 | 109 | 63 | 15 | 1752 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 6SB | 1049 | 995 | 1128 | 1526 | 914 | 71 | 9 | 0 | 0 | 0 | 229 | 634 | 6555 |
| ZONE-7 ALAMEDA | EXMCOENT=WT116 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12000 | 12000 |
| *** TOTAL *** | | | 2002 | 2012 | 2299 | 3235 | 4609 | 4237 | 4477 | 4804 | 4273 | 3307 | 2369 | 14043 | 51667 |
| ALAMEDA CO WD | M GW ENT=WT008 | 7SB | 0 | 0 | 0 | 0 | 0 | 716 | 740 | 740 | 716 | 556 | 0 | 0 | 3468 |
| ALAMEDA CO WD | STOR ENT=WT060 | 7SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 1000 |
| ALAMEDA CO WD | M&I ENT=WT010 | 8SB | 2009 | 1389 | 2009 | 2189 | 2262 | 2189 | 2262 | 2262 | 2189 | 2262 | 2189 | 2221 | 25432 |
| ALAMEDA CO WD | EXMCOENT=WT116 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12100 | 12100 |
| *** TOTAL *** | | | 2009 | 1389 | 2009 | 2189 | 2262 | 2905 | 3002 | 3002 | 2905 | 2818 | 2189 | 15321 | 42000 |
| SANTA CLARA VWD | M&I ENT=WT010 | 9SB | 3740 | 3570 | 3740 | 4649 | 7820 | 8143 | 8891 | 8721 | 8160 | 6825 | 6035 | 4506 | 74800 |
| SANTA CLARA VWD | M GW ENT=WT008 | 9SB | 0 | 0 | 850 | 2261 | 1071 | 935 | 459 | 629 | 850 | 2125 | 1020 | 0 | 10200 |
| SANTA CLARA VWD | EXMCOENT=WT116 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15000 | 15000 |
| *** TOTAL *** | | | 3740 | 3570 | 4590 | 6910 | 8891 | 9078 | 9350 | 9350 | 9010 | 8950 | 7055 | 19506 | 100000 |
| SAN LUIS OBISPO | PURPOOLA=WT112 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24212 | 24212 |
| SAN LUIS OBISPO | M&I ENT=WT010 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 195 | 195 | 390 |
| SAN LUIS OBISPO | M&I ENT=WT010 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 199 | 199 | 398 |

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FILE DUMP

FILE IDENTIFICATION: U199696 08/26/96. SHEET 2

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 394 | 24606 | 25000 |
| SANTA BARBARA | PURPOOLA=WT112 | 3A | 3557 | 3557 | 3557 | 3558 | 3558 | 3558 | 3558 | 3558 | 3558 | 3558 | 3558 | 0 | 39135 |
| SANTA BARBARA | M&I ENT=WT010 | 35 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3851 | 3851 |
| *** TOTAL *** | | | 3557 | 3557 | 3557 | 3558 | 3558 | 3558 | 3558 | 3558 | 3558 | 3558 | 3558 | 3851 | 42986 |
| DUDLEY RIDGE WD | AGR ENT=WT001 | 8D | 1800 | 5000 | 2000 | 1000 | 2800 | 7200 | 9200 | 9000 | 3000 | 1000 | 800 | 570 | 43370 |
| DUDLEY RIDGE WD | A GW ENT=WT022 | 8D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4000 | 4000 | 2000 | 10000 |
| *** TOTAL *** | | | 1800 | 5000 | 2000 | 1000 | 2800 | 7200 | 9200 | 9000 | 3000 | 5000 | 4800 | 2570 | 53370 |
| EMPIRE WS ID | AGR ENT=WT001 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | WETAWTHR=WT007 | 8C | 400 | 400 | 400 | 0 | 100 | 500 | 500 | 500 | 198 | 0 | 0 | 0 | 2998 |
| *** TOTAL *** | | | 460 | 490 | 580 | 240 | 400 | 980 | 1040 | 1040 | 468 | 120 | 90 | 90 | 5998 |
| KERN COUNTY WA | EXACDENT=WT115 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 121300 | 121300 |
| KERN COUNTY WA | EXMCDENT=WT116 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1700 | 1700 |
| KERN COUNTY WA | AGR ENT=WT001 | 9 | 600 | 1000 | 1000 | 9800 | 10200 | 15750 | 21300 | 19980 | 7260 | 3840 | 3840 | 5000 | 99570 |
| KERN COUNTY WA | CARY OVR=WT027 | 9 | 3000 | 3000 | 5000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11000 |
| KERN COUNTY WA | M&I ENT=WT010 | 10A | 50 | 50 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 50 | 50 | 1000 |
| KERN COUNTY WA | AGR ENT=WT001 | 10A | 2898 | 18996 | 2666 | 3345 | 4342 | 39735 | 59173 | 51175 | 15088 | 7859 | 5359 | 3158 | 213794 |
| KERN COUNTY WA | X82 ORD=WT051 | 10A | 0 | 8699 | 8307 | 0 | 0 | 0 | 0 | 0 | 3100 | 2000 | 1000 | 1000 | 24106 |
| KERN COUNTY WA | M&I ENT=WT010 | 11B | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 1800 |
| KERN COUNTY WA | AGR ENT=WT001 | 11B | 2660 | 5320 | 9640 | 9640 | 11800 | 17280 | 25120 | 20600 | 3485 | 2660 | 1330 | 1426 | 110961 |
| KERN COUNTY WA | M&I ENT=WT010 | 12E | 2110 | 1990 | 2300 | 2490 | 3010 | 3220 | 3500 | 3450 | 2920 | 2610 | 2000 | 2110 | 31710 |
| KERN COUNTY WA | M GW ENT=WT008 | 12E | 250 | 300 | 500 | 500 | 1700 | 11185 | 11225 | 13635 | 5225 | 5940 | 6320 | 6410 | 63190 |
| KERN COUNTY WA | AGR ENT=WT001 | 12E | 0 | 0 | 2250 | 5776 | 12500 | 24660 | 28760 | 30560 | 13620 | 4859 | 2000 | 1700 | 126685 |
| KERN COUNTY WA | CARY OVR=WT027 | 12E | 15000 | 15000 | 15000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 45000 |
| KERN COUNTY WA | 78MWD 30=WT016 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2047 | 6500 | 6500 | 6500 | 21547 |
| KERN COUNTY WA | X82 ORD=WT051 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1239 | 5000 | 5000 | 5000 | 16239 |
| KERN COUNTY WA | X82 MWD=WT052 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 323 | 1000 | 1000 | 1000 | 3323 |
| KERN COUNTY WA | M GW ENT=WT008 | 13B | 0 | 0 | 0 | 0 | 0 | 6000 | 7000 | 6000 | 0 | 0 | 0 | 0 | 19000 |
| KERN COUNTY WA | AGR ENT=WT001 | 13B | 0 | 1400 | 1000 | 2300 | 4500 | 18000 | 15350 | 10600 | 0 | 0 | 3300 | 10500 | 66950 |
| KERN COUNTY WA | X82 ORD=WT051 | 13B | 3800 | 2000 | 248 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6048 |
| KERN COUNTY WA | M&I ENT=WT010 | 14A | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 67 | 63 | 800 |
| KERN COUNTY WA | AGR ENT=WT001 | 14A | 200 | 700 | 2100 | 2000 | 1000 | 4100 | 6000 | 4400 | 700 | 400 | 100 | 600 | 22300 |
| KERN COUNTY WA | CARY OVR=WT027 | 14A | 200 | 700 | 2100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3000 |
| KERN COUNTY WA | AGR ENT=WT001 | 14B | 2300 | 4600 | 8200 | 4500 | 3600 | 12000 | 14600 | 12900 | 3200 | 2000 | 1500 | 2700 | 72100 |
| KERN COUNTY WA | CARY OVR=WT027 | 14B | 2300 | 4600 | 8200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15100 |
| KERN COUNTY WA | AGR ENT=WT001 | 14C | 700 | 1300 | 1800 | 2400 | 2500 | 5200 | 6200 | 5700 | 1700 | 800 | 1100 | 1700 | 31100 |
| KERN COUNTY WA | CARY OVR=WT027 | 14C | 700 | 1300 | 1800 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3800 |
| KERN COUNTY WA | AGR ENT=WT001 | 15A | 600 | 1200 | 1700 | 3000 | 800 | 5500 | 5400 | 3600 | 2100 | 3100 | 500 | 1000 | 28500 |
| KERN COUNTY WA | CARY OVR=WT027 | 15A | 600 | 1200 | 900 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2700 |
| KERN COUNTY WA | M&I ENT=WT010 | 16A | 0 | 0 | 0 | 200 | 300 | 400 | 400 | 400 | 300 | 200 | 0 | 0 | 2200 |
| KERN COUNTY WA | AGR ENT=WT001 | 16A | 300 | 100 | 300 | 1080 | 1696 | 2736 | 3544 | 2044 | 500 | 700 | 100 | 300 | 13400 |
| KERN COUNTY WA | CARY OVR=WT027 | 16A | 900 | 700 | 600 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2200 |
| KERN COUNTY WA | M GW ENT=WT008 | 31A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | AGR ENT=WT001 | 31A | 5000 | 4000 | 4000 | 7000 | 11000 | 16300 | 17000 | 9000 | 5500 | 4600 | 2600 | 3000 | 89000 |
| *** TOTAL *** | | | 44385 | 78372 | 79928 | 54348 | 69265 | 182383 | 224889 | 194361 | 68624 | 54385 | 43816 | 176367 | 1271123 |
| [illegible] | AGR ENT=WT001 | 2A | 114 | 171 | 342 | 456 | 570 | 912 | 1026 | 1026 | 513 | 228 | 171 | 171 | 5700 |
| [illegible] | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

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| | | | | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF KINGS | AGR | ENT=WT001 | 8C | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 400 | 0 | 400 | 400 | 400 | 4000 |
| OAK FLAT WD | AGR | ENT=WT001 | 2A | 114 | 171 | 342 | 456 | 570 | 912 | 1026 | 1026 | 513 | 228 | 171 | 171 | 5700 |
| *** TOTAL *** | | | | 114 | 171 | 342 | 456 | 570 | 912 | 1026 | 1026 | 513 | 228 | 171 | 171 | 5700 |
| TULARE LK BWSD | AGR | ENT=WT001 | 8C | 0 | 0 | 0 | 1000 | 2800 | 8400 | 9600 | 8400 | 800 | 400 | 6800 | 7200 | 45400 |
| TULARE LK BWSD | CYOV | ENT=WT069 | 8C | 10000 | 6000 | 4000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20000 |
| TULARE LK BWSD | EXACO | ENT=WT115 | 8C | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2000 | 2000 |
| TULARE LK BWSD | AGR | ENT=WT001 | 8D | 0 | 0 | 0 | 1500 | 4200 | 12600 | 14400 | 12600 | 1200 | 600 | 10200 | 10800 | 68100 |
| TULARE LK BWSD | CYOV | ENT=WT069 | 8D | 15000 | 9000 | 6000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30000 |
| TULARE LK BWSD | EXACO | ENT=WT115 | 8D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3000 | 3000 |
| *** TOTAL *** | | | | 25000 | 15000 | 10000 | 2500 | 7000 | 21000 | 24000 | 21000 | 2000 | 1000 | 17000 | 23000 | 168500 |
| AVEK WA | PURPOOL | A=WT112 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 81578 | 81578 |
| AVEK WA | AGR | ENT=WT001 | 19 | 3 | 3 | 105 | 120 | 140 | 70 | 85 | 95 | 87 | 72 | 31 | 11 | 822 |
| AVEK WA | M&I | ENT=WT010 | 19C | 473 | 498 | 513 | 608 | 685 | 752 | 830 | 844 | 772 | 629 | 567 | 538 | 7709 |
| AVEK WA | AGR | ENT=WT001 | 19C | 10 | 115 | 816 | 1063 | 1361 | 1726 | 1991 | 1631 | 1106 | 263 | 125 | 25 | 10232 |
| AVEK WA | TRANSFER | =WT067 | 19C | 18 | 79 | 92 | 108 | 80 | 150 | 205 | 160 | 180 | 140 | 120 | 50 | 1382 |
| AVEK WA | M&I | ENT=WT010 | 20A | 1307 | 1218 | 1784 | 2738 | 3018 | 3721 | 4801 | 4724 | 4298 | 2580 | 1771 | 1629 | 33589 |
| AVEK WA | AGR | ENT=WT001 | 20A | 9 | 9 | 9 | 10 | 10 | 10 | 11 | 10 | 10 | 10 | 9 | 9 | 116 |
| AVEK WA | TRANSFER | =WT067 | 20A | 7 | 10 | 12 | 27 | 33 | 42 | 59 | 49 | 34 | 22 | 6 | 2 | 303 |
| AVEK WA | M&I | ENT=WT010 | 20B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AVEK WA | M&I | ENT=WT010 | 22A | 115 | 100 | 144 | 278 | 295 | 389 | 539 | 442 | 404 | 233 | 158 | 153 | 3250 |
| AVEK WA | AGR | ENT=WT001 | 22A | 2 | 2 | 92 | 92 | 182 | 182 | 182 | 182 | 92 | 92 | 2 | 2 | 1104 |
| *** TOTAL *** | | | | 1944 | 2034 | 3567 | 5044 | 5804 | 7042 | 8703 | 8137 | 6983 | 4041 | 2789 | 83997 | 140085 |
| CASTAIC LAKE WA | M&I | ENT=WT010 | 30 | 1645 | 1526 | 2014 | 2157 | 2461 | 2669 | 2843 | 2867 | 2759 | 2406 | 1780 | 1973 | 27100 |
| CASTAIC LAKE WA | AGR | ENT=WT001 | 31A | 254 | 381 | 762 | 1016 | 1270 | 2032 | 2286 | 2286 | 1143 | 508 | 381 | 381 | 12700 |
| *** TOTAL *** | | | | 1899 | 1907 | 2776 | 3173 | 3731 | 4701 | 5129 | 5153 | 3902 | 2914 | 2161 | 2354 | 39800 |
| COACHELLA VALLY | M&I | ENT=WT010 | 26A | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| *** TOTAL *** | | | | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| CRESTLINE-LA WA | M&I | ENT=WT010 | 24 | 95 | 61 | 52 | 111 | 152 | 164 | 242 | 253 | 232 | 198 | 200 | 190 | 1950 |
| CRESTLINE-LA WA | STOR | ENT=WT060 | 24 | 0 | 0 | 0 | 0 | 0 | 1100 | 1100 | 0 | 0 | 0 | 0 | 0 | 2200 |
| *** TOTAL *** | | | | 95 | 61 | 52 | 111 | 152 | 1264 | 1342 | 253 | 232 | 198 | 200 | 190 | 4150 |
| DESERT WA | EXCHMENT | =WT099 | 26A | 6505 | 5876 | 6505 | 6296 | 6505 | 6296 | 117 | 0 | 0 | 0 | 0 | 0 | 38100 |
| *** TOTAL *** | | | | 6505 | 5876 | 6505 | 6296 | 6505 | 6296 | 117 | 0 | 0 | 0 | 0 | 0 | 38100 |
| LITTLEROCK CR | M&I | ENT=WT010 | 21 | 60 | 60 | 130 | 150 | 200 | 240 | 280 | 280 | 240 | 150 | 80 | 60 | 1930 |
| LITTLEROCK CR | AGR | ENT=WT001 | 21 | 0 | 0 | 30 | 40 | 50 | 60 | 60 | 60 | 40 | 30 | 0 | 0 | 370 |
| *** TOTAL *** | | | | 60 | 60 | 160 | 190 | 250 | 300 | 340 | 340 | 280 | 180 | 80 | 60 | 2300 |
| METROPOLITAN WD | EXMCO | ENT=WT116 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100000 | 100000 | |
| METROPOLITAN WD | STOR | ENT=WT060 | 10A | 0 | 0 | 0 | 0 | 25000 | 25000 | 25000 | 0 | 0 | 0 | 0 | 0 | 75000 |
| METROPOLITAN WD | M&I | ENT=WT010 | 26A | 500 | 0 | 500 | 10500 | 21500 | 27500 | 26500 | 28500 | 14500 | 9500 | 3500 | 3500 | 146500 |
| METROPOLITAN WD | 78 EX | GW=WT037 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2047 | 6500 | 6500 | 6500 | 21547 |
| METROPOLITAN WD | -78EX | GW=WT038 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2047 | -6500 | -6500 | -6500 | -21547 |
| METROPOLITAN WD | X82 | GW=WT054 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 323 | 1000 | 1000 | 1000 | 3323 |

14112

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FILE IDENTIFICATION: U199696 FILE DUMP 08/26/96. SHEET 4

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METROPOLITAN WD | -X82 GW=WT055 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -323 | -1000 | -1000 | -1000 | -3323 |
| METROPOLITAN WD | M&I ENT=WT010 | 28H | 4000 | 1500 | 3000 | 4000 | 6000 | 6000 | 6000 | 6000 | 6000 | 4000 | 4000 | 4000 | 54500 |
| METROPOLITAN WD | BYPS ENT=WT059 | 28H | 0 | 0 | 5000 | 10000 | 10000 | 13000 | 13000 | 14000 | 6000 | 0 | 0 | 0 | 71000 |
| METROPOLITAN WD | M&I ENT=WT010 | 28J | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 4800 |
| METROPOLITAN WD | M&I ENT=WT010 | 30 | 11000 | 8000 | 10000 | 23000 | 20000 | 20000 | 29000 | 29000 | 26000 | 36000 | 37000 | 38000 | 287000 |
| *** TOTAL *** | | | 15900 | 9900 | 18900 | 47900 | 82900 | 91900 | 99900 | 77900 | 52900 | 49900 | 44900 | 145900 | 738800 |
| MOJAVE WA | TRANMENT=WT083 | 19C | 18 | 79 | 92 | 108 | 80 | 150 | 205 | 160 | 180 | 140 | 120 | 50 | 1382 |
| MOJAVE WA | M GW ENT=WT008 | 24 | 1082 | 921 | 1008 | 1192 | 1920 | 1850 | 795 | 1040 | 2120 | 2360 | 2380 | 1950 | 18618 |
| *** TOTAL *** | | | 1100 | 1000 | 1100 | 1300 | 2000 | 2000 | 1000 | 1200 | 2300 | 2500 | 2500 | 2000 | 20000 |
| PALMDALE WD | TRANMENT=WT083 | 20A | 7 | 10 | 12 | 27 | 33 | 42 | 59 | 49 | 34 | 22 | 6 | 2 | 303 |
| PALMDALE WD | M&I ENT=WT010 | 20B | 1693 | 1140 | 1203 | 1273 | 1870 | 1861 | 1844 | 1854 | 1869 | 1127 | 723 | 540 | 16997 |
| *** TOTAL *** | | | 1700 | 1150 | 1215 | 1300 | 1903 | 1903 | 1903 | 1903 | 1903 | 1149 | 729 | 542 | 17300 |
| SAN BERNARDINO | M&I ENT=WT010 | 26A | 500 | 500 | 500 | 1000 | 1500 | 2000 | 2000 | 2500 | 2500 | 2000 | 1500 | 500 | 17000 |
| SAN BERNARDINO | M GW ENT=WT008 | 26A | 500 | 500 | 500 | 1000 | 1000 | 1500 | 1500 | 1000 | 1000 | 500 | 500 | 500 | 10000 |
| *** TOTAL *** | | | 1000 | 1000 | 1000 | 2000 | 2500 | 3500 | 3500 | 3500 | 3500 | 2500 | 2000 | 1000 | 27000 |
| SAN GABRIEL | M GW ENT=WT008 | 26A | 0 | 0 | 0 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 0 | 16000 |
| *** TOTAL *** | | | 0 | 0 | 0 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 0 | 16000 |
| SAN GORGONIO | M GW ENT=WT008 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| VENTURA CO FCD | M GW ENT=WT008 | 29H | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 2000 | 5000 |
| VENTURA CO FCD | M&I ENT=WT010 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2500 | 2500 | 5000 |
| *** TOTAL *** | | | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3500 | 4500 | 10000 |
| SHELL CAL PROD. | REPAYMNT=WT009 | 11B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FISH & GAME | REC/F&WL=WT002 | 3 | 20 | 20 | 20 | 50 | 50 | 150 | 200 | 200 | 200 | 50 | 20 | 20 | 1000 |
| FISH & GAME | REC/F&WL=WT002 | 5 | 0 | 0 | 10 | 30 | 40 | 40 | 40 | 30 | 10 | 0 | 0 | 0 | 200 |
| *** TOTAL *** | | | 20 | 20 | 30 | 80 | 90 | 190 | 240 | 230 | 210 | 50 | 20 | 20 | 1200 |
| PARKS & RECREAT | REC/F&WL=WT002 | 3 | 3 | 3 | 6 | 8 | 13 | 31 | 31 | 31 | 31 | 18 | 10 | 4 | 189 |
| *** TOTAL *** | | | 3 | 3 | 6 | 8 | 13 | 31 | 31 | 31 | 31 | 18 | 10 | 4 | 189 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 5SB | 34 | 30 | 34 | 33 | 34 | 33 | 34 | 34 | 33 | 34 | 33 | 34 | 400 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 1 | 5 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 50 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 20A | 10 | 10 | 10 | 20 | 20 | 20 | 26 | 24 | 20 | 20 | 10 | 10 | 200 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 24 | 9 | 9 | 9 | 18 | 18 | 18 | 23 | 22 | 18 | 18 | 9 | 9 | 180 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 28J | 60 | 60 | 60 | 120 | 120 | 120 | 178 | 172 | 120 | 120 | 60 | 60 | 1250 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 28H | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| *** TOTAL *** | | | 388 | 383 | 388 | 727 | 728 | 727 | 965 | 926 | 727 | 728 | 386 | 387 | 7460 |
| USBR (SAN LUIS) | FEDERAL =WT015 | 3A | 4800 | 4200 | 6400 | 8600 | 12400 | 14600 | 15200 | 14600 | 12600 | 7600 | 8500 | 6500 | 116000 |
| [illegible] | [illegible] | [illegible] | 10 | 10 | 11 | 26 | 28 | 79 | 102 | 102 | 102 | 31 | 12 | 10 | 523 |

14112

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COUNTY OF BUTTE TOTAL =      800
            TOT  ENT =      800  M&I  ENT =      800
PLUMAS CO FCWCD TOTAL =     1350
            TOT  ENT =     1350  M&I  ENT =     1350
YUBA CITY       TOTAL =     3700
            TOT  ENT =     3700  M&I  ENT =     3700
NAPA CO FCWCD   TOTAL =    10425
            TOT  ENT =    10425  M&I  ENT =    10425
SOLANO CO WA    TOTAL =    40810
            TOT  ENT =    32310  M&I  ENT =    14000  BEN ENT  =    13090  VAL ENT  =     2900  EXMCOENT =     2320
            TOT MISC =     8500  VAL PMT  =     8500
ZONE-7 ALAMEDA  TOTAL =    53342
            TOT  ENT =    45347  M&I  ENT =    25369  M GW ENT =    14110  AGR  ENT =     5868
            TOT MISC =     7995  GEN WLNG =      667  LOCAL    =     7328
ALAMEDA CO WD   TOTAL =    39800
            TOT  ENT =    34800  M&I  ENT =    27387  M GW ENT =     7413
            TOT MISC =     5000  LOCAL    =     5000
SANTA CLARA VWD TOTAL =   100000
            TOT  ENT =   100000  M&I  ENT =    26400  M GW ENT =     3600  STOR ENT =    40000  EXMCOENT =    30000
SAN LUIS OBISPO TOTAL =     5885
            TOT  ENT =     3676  M&I  ENT =     3676
            TOT MISC =     2209  PURPOOLA =     2209
SANTA BARBARA   TOTAL =    38986
            TOT  ENT =    22892  M&I  ENT =    22892
            TOT MISC =    16094  PURPOOLA =    16094
DUDLEY RIDGE WD TOTAL =    53370
            TOT  ENT =    53370  AGR  ENT =    52370  A GW ENT =     1000
EMPIRE WS ID    TOTAL =     3000
            TOT  ENT =     3000  AGR  ENT =     3000
KERN COUNTY WA  TOTAL =  1183993
            TOT  ENT =  1112730  M&I  ENT =    38210  M GW ENT =    83390  AGR  ENT =   934830  EXACOENT =    56300
            TOT MISC =    71263  78MWD 3C =    21547  X82  ORC =    46393  X82  MWD =     3323
COUNTY OF KINGS TOTAL =     4000
            TOT  ENT =     4000  AGR  ENT =     4000
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STATE OF CALIFORNIA
THE RESOURCES AGENCY

ANNUAL SUMMARY BY AGENCY, WATER TYPE
YEAR 1997

DEPARTMENT OF WATER RESOURCES
STATE WATER PROJECT ANALYSIS OFFICE

FILE ID: T199797

DATE: 09/12/97
PAGE: 2

```
OAK FLAT WD        TOTAL =     5700
              TOT  ENT =     5700  AGR  ENT =     5700

TULARE LK BWSD     TOTAL =   118500
              TOT  ENT =   118500  AGR  ENT =   118500

AVEK WA            TOTAL =   140118
              TOT  ENT =    60957  M&I  ENT =    44246  AGR  ENT =    16711
              TOT MISC =    79161  TRANSFER =     3725  PURPOOLA =    75436

CASTAIC LAKE WA TOTAL =    54200
              TOT  ENT =    40565  M&I  ENT =    21000  AGR  ENT =    16000  FLEXSTOR =     3565
              TOT MISC =    13635  PURPOOLA =    13635

COACHELLA VALLY TOTAL =    23100
              TOT  ENT =    23100  M&I  ENT =    23100

CRESTLINE-LA WA TOTAL =     1950
              TOT  ENT =     1950  M&I  ENT =     1950

DESERT WA          TOTAL =    38100
              TOT  ENT =    38100  EXCHMENT =    38100

LITTLEROCK CR      TOTAL =     2300
              TOT  ENT =     2300  M&I  ENT =     1930  AGR  ENT =      370

METROPOLITAN WD TOTAL = 1044100
              TOT  ENT = 1044100  M&I  ENT =   641014  BYPS ENT =   128086  STOR ENT =    75000  EXMCOENT =   200000

MOJAVE WA          TOTAL =    14600
              TOT  ENT =    14600  TRANMENT =     1500  M GW ENT =    13100

PALMDALE WD        TOTAL =    17300
              TOT  ENT =    17300  M&I  ENT =    17300
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14112

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| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *** TOTAL *** | | | 35 | 45 | 110 | 315 | 65 | 60 | 25 | 25 | 20 | 20 | 35 | 45 | 800 |
| PLUMAS CO FCWCD | M&I | ENT=WT010 | FR | 65 | 65 | 70 | 125 | 150 | 150 | 150 | 150 | 150 | 125 | 75 | 75 | 1350 |
| *** TOTAL *** | | | | 65 | 65 | 70 | 125 | 150 | 150 | 150 | 150 | 150 | 125 | 75 | 75 | 1350 |
| YUBA CITY | M&I | ENT=WT010 | FR | 0 | 0 | 0 | 0 | 0 | 500 | 1000 | 1200 | 500 | 500 | 0 | 0 | 3700 |
| *** TOTAL *** | | | | 0 | 0 | 0 | 0 | 0 | 500 | 1000 | 1200 | 500 | 500 | 0 | 0 | 3700 |
| NAPA CO FCWCD | M&I | ENT=WT010 | 3NB | 100 | 99 | 117 | 169 | 163 | 220 | 1833 | 1834 | 1722 | 1460 | 1348 | 1360 | 10425 |
| *** TOTAL *** | | | | 100 | 99 | 117 | 169 | 163 | 220 | 1833 | 1834 | 1722 | 1460 | 1348 | 1360 | 10425 |
| SOLANO CO WA | M&I | ENT=WT010 | 1NB | 450 | 450 | 475 | 1070 | 1420 | 1420 | 1420 | 1620 | 1620 | 1420 | 1370 | 1265 | 14000 |
| SOLANO CO WA | VAL PMT | =WT071 | 1NB | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 100 |
| SOLANO CO WA | EXMCOENT | =WT116 | 1NB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1060 | 1060 |
| SOLANO CO WA | BEN ENT | =WT046 | 3NA | 850 | 850 | 850 | 950 | 950 | 1300 | 1430 | 1400 | 1250 | 1250 | 1160 | 850 | 13090 |
| SOLANO CO WA | VAL ENT | =WT047 | 3NA | 0 | 0 | 0 | 0 | 0 | 500 | 500 | 500 | 500 | 500 | 400 | 0 | 2900 |
| SOLANO CO WA | VAL PMT | =WT071 | 3NA | 900 | 900 | 900 | 900 | 1000 | 500 | 500 | 500 | 500 | 400 | 500 | 900 | 8400 |
| SOLANO CO WA | EXMCOENT | =WT116 | 3NA | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1260 | 1260 |
| *** TOTAL *** | | | | 2200 | 2200 | 2225 | 2920 | 3370 | 3745 | 3875 | 4045 | 3895 | 3570 | 3430 | 5335 | 40810 |
| ZONE-7 ALAMEDA | AGR | ENT=WT001 | 1SB | 1 | 4 | 6 | 38 | 59 | 76 | 79 | 81 | 77 | 59 | 16 | 2 | 498 |
| ZONE-7 ALAMEDA | M&I | ENT=WT010 | 2SB | 452 | 437 | 483 | 727 | 1140 | 1140 | 1140 | 1140 | 1140 | 1002 | 698 | 604 | 10103 |
| ZONE-7 ALAMEDA | LOCAL | =WT024 | 2SB | 89 | 74 | 110 | 55 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 328 |
| ZONE-7 ALAMEDA | M GW | ENT=WT008 | 4SB | 850 | 770 | 850 | 1120 | 1170 | 1130 | 1170 | 1170 | 1170 | 860 | 830 | 860 | 11950 |
| ZONE-7 ALAMEDA | AGR | ENT=WT001 | 4SB | 34 | 106 | 124 | 228 | 463 | 482 | 502 | 475 | 181 | 202 | 98 | 29 | 2924 |
| ZONE-7 ALAMEDA | LOCAL | =WT024 | 4SB | 24 | 10 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 |
| ZONE-7 ALAMEDA | M GW | ENT=WT008 | 5SB | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 2160 |
| ZONE-7 ALAMEDA | AGR | ENT=WT001 | 5SB | 10 | 10 | 20 | 60 | 70 | 80 | 80 | 80 | 40 | 30 | 10 | 10 | 500 |
| ZONE-7 ALAMEDA | GEN WLNG | =WT079 | 6SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 667 | 0 | 0 | 0 | 667 |
| ZONE-7 ALAMEDA | M&I | ENT=WT010 | 6SB | 0 | 0 | 0 | 98 | 1483 | 2184 | 2626 | 2611 | 2211 | 2203 | 1260 | 590 | 15266 |
| ZONE-7 ALAMEDA | AGR | ENT=WT001 | 6SB | 15 | 78 | 122 | 188 | 250 | 284 | 314 | 265 | 200 | 137 | 78 | 15 | 1946 |
| ZONE-7 ALAMEDA | LOCAL | =WT024 | 6SB | 1146 | 1086 | 1255 | 1620 | 914 | 71 | 9 | 0 | 0 | 0 | 229 | 634 | 6964 |
| *** TOTAL *** | | | | 2801 | 2755 | 3152 | 4314 | 5729 | 5627 | 6100 | 6002 | 5866 | 4673 | 3399 | 2924 | 53342 |
| ALAMEDA CO WD | M GW | ENT=WT008 | 7SB | 0 | 0 | 0 | 0 | 0 | 500 | 500 | 500 | 913 | 2000 | 2000 | 1000 | 7413 |
| ALAMEDA CO WD | LOCAL | =WT024 | 7SB | 0 | 0 | 0 | 0 | 500 | 500 | 500 | 500 | 500 | 500 | 1000 | 1000 | 5000 |
| ALAMEDA CO WD | M&I | ENT=WT010 | 8SB | 2326 | 2101 | 2326 | 2251 | 2326 | 2251 | 2326 | 2326 | 2251 | 2326 | 2251 | 2326 | 27387 |
| *** TOTAL *** | | | | 2326 | 2101 | 2326 | 2251 | 2826 | 3251 | 3326 | 3326 | 3664 | 4826 | 5251 | 4326 | 39800 |
| SANTA CLARA VWD | M&I | ENT=WT010 | 9SB | 1000 | 1000 | 2200 | 2200 | 2450 | 3100 | 3500 | 3500 | 3150 | 1750 | 1150 | 1400 | 26400 |
| SANTA CLARA VWD | M GW | ENT=WT008 | 9SB | 0 | 0 | 300 | 350 | 400 | 450 | 550 | 550 | 500 | 300 | 200 | 0 | 3600 |
| SANTA CLARA VWD | STOR | ENT=WT060 | 10A | 0 | 0 | 0 | 0 | 0 | 20000 | 20000 | 0 | 0 | 0 | 0 | 0 | 40000 |
| SANTA CLARA VWD | EXMCOENT | =WT116 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30000 | 30000 |
| *** TOTAL *** | | | | 1000 | 1000 | 2500 | 2550 | 2850 | 23550 | 24050 | 4050 | 3650 | 2050 | 1350 | 31400 | 100000 |
| SAN LUIS OBISPO | PURPOOLA | =WT112 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2209 | 2209 |
| SAN LUIS OBISPO | M&I | ENT=WT010 | 3A | 111 | 100 | 120 | 122 | 224 | 225 | 225 | 225 | 225 | 225 | 210 | 293 | 2305 |

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FILE IDENTIFICATION: T199797 FILE DUMP 09/12/97. SHEET 2

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAN LUIS OBISPO | TRANSFER=WT067 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SAN LUIS OBISPO | M&I ENT=WT010 | 35 | 89 | 82 | 85 | 105 | 114 | 134 | 155 | 155 | 133 | 118 | 106 | 95 | 1371 |
| *** TOTAL *** | | | 200 | 182 | 205 | 227 | 338 | 359 | 380 | 380 | 358 | 343 | 316 | 2597 | 5885 |
| SANTA BARBARA | PURPOOLA=WT112 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16094 | 16094 |
| SANTA BARBARA | M&I ENT=WT010 | 35 | 1423 | 1279 | 1509 | 1903 | 2217 | 2338 | 2469 | 2444 | 2232 | 1964 | 1643 | 1471 | 22892 |
| *** TOTAL *** | | | 1423 | 1279 | 1509 | 1903 | 2217 | 2338 | 2469 | 2444 | 2232 | 1964 | 1643 | 17565 | 38986 |
| DUDLEY RIDGE WD | AGR ENT=WT001 | 8D | 1900 | 2300 | 2200 | 3300 | 4200 | 9700 | 12500 | 10800 | 1900 | 1700 | 1300 | 570 | 52370 |
| DUDLEY RIDGE WD | A GW ENT=WT022 | 8D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 1000 |
| *** TOTAL *** | | | 1900 | 2300 | 2200 | 3300 | 4200 | 9700 | 12500 | 10800 | 1900 | 1700 | 1300 | 1570 | 53370 |
| EMPIRE WS ID | AGR ENT=WT001 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| *** TOTAL *** | | | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| KERN COUNTY WA | EXACOENT=WT115 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | EXMCOENT=WT116 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | AGR ENT=WT001 | 9 | 700 | 700 | 5600 | 10400 | 12500 | 19640 | 26000 | 20860 | 6900 | 3800 | 3800 | 3910 | 114810 |
| KERN COUNTY WA | EXACOENT=WT115 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 45000 | 45000 |
| KERN COUNTY WA | M&I ENT=WT010 | 10A | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 500 |
| KERN COUNTY WA | AGR ENT=WT001 | 10A | 1950 | 6100 | 13600 | 14800 | 16100 | 40350 | 60000 | 53000 | 17800 | 9400 | 6250 | 1550 | 240900 |
| KERN COUNTY WA | X82 ORO=WT051 | 10A | 0 | 0 | 6205 | 5812 | 5813 | 6276 | 0 | 0 | 0 | 0 | 0 | 0 | 24106 |
| KERN COUNTY WA | M&I ENT=WT010 | 11B | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 166 | 166 | 166 | 166 | 167 | 2000 |
| KERN COUNTY WA | AGR ENT=WT001 | 11B | 1267 | 2533 | 10453 | 10453 | 13067 | 24946 | 31360 | 26133 | 5227 | 2613 | 1307 | 1306 | 130665 |
| KERN COUNTY WA | M&I ENT=WT010 | 12E | 2110 | 1990 | 2300 | 2490 | 3010 | 3220 | 3500 | 3450 | 2920 | 2610 | 2000 | 2110 | 31710 |
| KERN COUNTY WA | M GW ENT=WT008 | 12E | 0 | 0 | 0 | 0 | 2800 | 14685 | 13025 | 15035 | 5225 | 5940 | 7320 | 7360 | 71390 |
| KERN COUNTY WA | AGR ENT=WT001 | 12E | 0 | 0 | 0 | 3000 | 10300 | 32000 | 33500 | 24300 | 3346 | 1000 | 1000 | 1209 | 109655 |
| KERN COUNTY WA | 78MWD 30=WT016 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2047 | 6500 | 6500 | 6500 | 21547 |
| KERN COUNTY WA | X82 ORO=WT051 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1239 | 5000 | 5000 | 5000 | 16239 |
| KERN COUNTY WA | X82 MWD=WT052 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 323 | 1000 | 1000 | 1000 | 3323 |
| KERN COUNTY WA | EXACOENT=WT115 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10000 | 10000 |
| KERN COUNTY WA | M GW ENT=WT008 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12000 |
| KERN COUNTY WA | AGR ENT=WT001 | 13B | 0 | 0 | 2000 | 1000 | 5000 | 10100 | 9800 | 8900 | 300 | 200 | 2500 | 2000 | 41800 |
| KERN COUNTY WA | X82 ORO=WT051 | 13B | 3800 | 2000 | 248 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6048 |
| KERN COUNTY WA | M&I ENT=WT010 | 14A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | AGR ENT=WT001 | 14A | 500 | 750 | 2000 | 2400 | 2300 | 5600 | 7850 | 4700 | 1500 | 300 | 200 | 300 | 28400 |
| KERN COUNTY WA | AGR ENT=WT001 | 14B | 1700 | 2000 | 7600 | 5400 | 7500 | 16000 | 21300 | 13000 | 2700 | 2000 | 1300 | 2200 | 82700 |
| KERN COUNTY WA | AGR ENT=WT001 | 14C | 750 | 1250 | 1800 | 3000 | 4300 | 6700 | 9500 | 5600 | 2300 | 1100 | 700 | 1000 | 38000 |
| KERN COUNTY WA | AGR ENT=WT001 | 15A | 400 | 800 | 2500 | 2500 | 4900 | 6400 | 7500 | 4900 | 2500 | 3000 | 2300 | 2000 | 40700 |
| KERN COUNTY WA | M&I ENT=WT010 | 16A | 0 | 0 | 0 | 480 | 496 | 480 | 744 | 744 | 424 | 480 | 152 | 0 | 4000 |
| KERN COUNTY WA | AGR ENT=WT001 | 16A | 150 | 200 | 600 | 1680 | 2496 | 2836 | 4094 | 2544 | 1500 | 1100 | 500 | 500 | 18200 |
| KERN COUNTY WA | EXACOENT=WT115 | 16A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1300 | 1300 |
| KERN COUNTY WA | M GW ENT=WT008 | 31A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | AGR ENT=WT001 | 31A | 960 | 960 | 5500 | 6500 | 11000 | 17500 | 19000 | 12580 | 6500 | 4000 | 2500 | 2000 | 89000 |
| *** TOTAL *** | | | 14479 | 19475 | 60623 | 71132 | 102799 | 209950 | 251390 | 199962 | 62967 | 50259 | 44520 | 96437 | 1183993 |
| TULARE LK BWSD | AGR ENT=WT001 | 8C | 0 | 0 | 648 | 2836 | 1416 | 8880 | 9124 | 8880 | 1184 | 1012 | 5872 | 7548 | 47400 |
| TULARE LK BWSD | AGR ENT=WT001 | 8D | 0 | 0 | 972 | 4254 | 2124 | 13320 | 13686 | 13320 | 1776 | 1518 | 8808 | 11322 | 71100 |
| *** TOTAL *** | | | 0 | 0 | 1620 | 7090 | 3540 | 22200 | 22810 | 22200 | 2960 | 2530 | 14680 | 18870 | 118500 |
| AVEK WA | PURPOOLA=WT112 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AVEK WA | AGR ENT=WT001 | 10 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

14112

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KERN COUNTY WA | AGR ENT=WT001 | 31A | 960 | 960 | 5500 | 6500 | 11000 | 17500 | 19000 | 12580 | 6500 | 4000 | 2500 | 2000 | 89000 | |
| *** TOTAL *** | | | 14479 | 19475 | 60623 | 71132 | 102799 | 209950 | 251390 | 199962 | 62967 | 50259 | 44520 | 96437 | 1183993 | |
| COUNTY OF KINGS | AGR ENT=WT001 | 8C | 0 | 0 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 4000 | |
| *** TOTAL *** | | | 114 | 171 | 342 | 498 | 370 | 612 | 1020 | 1020 | 918 | 246 | 171 | 171 | 2400 | |
| TULARE LK BWSD | AGR ENT=WT001 | 8C | 0 | 0 | 648 | 2836 | 1416 | 8880 | 9124 | 8880 | 1184 | 1012 | 5872 | 7548 | 47400 | |
| TULARE LK BWSD | AGR ENT=WT001 | 8D | 0 | 0 | 972 | 4254 | 2124 | 13320 | 13686 | 13320 | 1776 | 1518 | 8808 | 11322 | 71100 | |
| *** TOTAL *** | | | 0 | 0 | 1620 | 7090 | 3540 | 22200 | 22810 | 22200 | 2960 | 2530 | 14680 | 18870 | 118500 | |
| AVEK WA | PURPOOLA=WT112 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 75436 | 75436 | |
| AVEK WA | AGR ENT=WT001 | 19 | 3 | 3 | 4 | 123 | 143 | 49 | 89 | 94 | 94 | 65 | 33 | 12 | 712 | |
| AVEK WA | M&I ENT=WT010 | 19C | 430 | 454 | 476 | 595 | 710 | 781 | 869 | 894 | 776 | 639 | 566 | 506 | 7696 | |
| AVEK WA | AGR ENT=WT001 | 19C | 95 | 312 | 1360 | 1407 | 1541 | 2646 | 2623 | 2350 | 1808 | 452 | 230 | 20 | 14844 | |
| AVEK WA | TRANSFER=WT067 | 19C | 120 | 66 | 81 | 313 | 425 | 466 | 472 | 469 | 445 | 400 | 39 | 52 | 3348 | |
| AVEK WA | M&I ENT=WT010 | 20A | 1070 | 1223 | 1488 | 2400 | 2989 | 3604 | 4297 | 4039 | 3942 | 2802 | 2048 | 1545 | 31447 | |
| AVEK WA | AGR ENT=WT001 | 20A | 9 | 9 | 9 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 9 | 9 | 115 | |
| AVEK WA | TRANSFER=WT067 | 20A | 15 | 8 | 16 | 24 | 32 | 55 | 48 | 51 | 50 | 38 | 21 | 19 | 377 | |
| AVEK WA | M&I ENT=WT010 | 20B | 33 | 46 | 49 | 84 | 109 | 137 | 151 | 173 | 76 | 210 | 105 | 79 | 1252 | |
| AVEK WA | M&I ENT=WT010 | 22A | 121 | 153 | 154 | 302 | 295 | 405 | 556 | 513 | 616 | 366 | 209 | 161 | 3851 | |
| AVEK WA | AGR ENT=WT001 | 22A | 0 | 10 | 70 | 70 | 150 | 180 | 190 | 220 | 100 | 30 | 20 | 0 | 1040 | |
| *** TOTAL *** | | | 1896 | 2284 | 3707 | 5328 | 6404 | 8333 | 9305 | 8813 | 7917 | 5012 | 3280 | 77839 | 140118 | |
| CASTAIC LAKE WA | M&I ENT=WT010 | 30 | 1010 | 1010 | 1010 | 1230 | 1550 | 2280 | 3060 | 3170 | 2780 | 1850 | 1040 | 1010 | 21000 | |
| CASTAIC LAKE WA | PURPOOLA=WT112 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13635 | 13635 | |
| CASTAIC LAKE WA | FLEXSTOR=WT117 | 30 | 3565 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3565 | |
| CASTAIC LAKE WA | AGR ENT=WT001 | 31A | 1000 | 1500 | 1500 | 1500 | 1500 | 1500 | 2000 | 2500 | 500 | 0 | 1500 | 1000 | 16000 | |
| *** TOTAL *** | | | 5575 | 2510 | 2510 | 2730 | 3050 | 3780 | 5060 | 5670 | 3280 | 1850 | 2540 | 15645 | 54200 | |
| COACHELLA VALLY | M&I ENT=WT010 | 26A | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 | |
| *** TOTAL *** | | | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 | |
| CRESTLINE-LA WA | M&I ENT=WT010 | 24 | 95 | 61 | 52 | 111 | 152 | 164 | 242 | 253 | 232 | 198 | 200 | 190 | 1950 | |
| *** TOTAL *** | | | 95 | 61 | 52 | 111 | 152 | 164 | 242 | 253 | 232 | 198 | 200 | 190 | 1950 | |
| DESERT WA | EXCHMENT=WT099 | 26A | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 | |
| *** TOTAL *** | | | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 | |
| LITTLEROCK CR | M&I ENT=WT010 | 21 | 60 | 60 | 130 | 150 | 200 | 240 | 280 | 280 | 240 | 150 | 80 | 60 | 1930 | |
| LITTLEROCK CR | AGR ENT=WT001 | 21 | 0 | 0 | 30 | 40 | 50 | 60 | 60 | 60 | 40 | 30 | 0 | 0 | 370 | |
| *** TOTAL *** | | | 60 | 60 | 160 | 190 | 250 | 300 | 340 | 340 | 280 | 180 | 80 | 60 | 2300 | |
| METROPOLITAN WD | EXMCOENT=WT116 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200000 | 200000 | |
| METROPOLITAN WD | STOR ENT=WT060 | ~~10A~~ | 0 | 0 | 0 | 0 | 25000 | 25000 | 25000 | 0 | 0 | 0 | 0 | 0 | 75000 | |
| METROPOLITAN WD | M&I ENT=WT010 | 26A | 4000 | 5000 | 6400 | 38200 | 43600 | 41500 | 43600 | 36100 | 29700 | 24300 | 14400 | 4491 | 291291 | |
| METROPOLITAN WD | 78 EX GW=WT037 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| METROPOLITAN WD | -78EX GW=WT038 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| METROPOLITAN WD | X82 GW=WT054 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| METROPOLITAN WD | -X82 GW=WT055 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | |
| METROPOLITAN WD | M&I ENT=WT010 | 28H | 4300 | 3200 | 4660 | 4300 | 6400 | 8600 | 8600 | 9600 | 7500 | 6400 | 5300 | 5300 | 74160 | |
| METROPOLITAN WD | BYPS ENT=WT059 | 28H | 0 | 0 | 0 | 19512 | 17900 | 19512 | 20000 | 20162 | 19000 | 4000 | 4000 | 4000 | 128086 | |
| METROPOLITAN WD | M&I ENT=WT010 | 28J | 340 | 340 | 340 | 323 | 323 | 323 | 420 | 420 | 420 | 300 | 300 | 300 | 4149 | |

14112

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FILE IDENTIFICATION: T199797 FILE DUMP 09/12/97. SHEET 4

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METROPOLITAN WD | M&I ENT=WT010 | 20 | 19300 | 19300 | 25700 | 22688 | 20100 | 22688 | 21100 | 24238 | 21100 | 28600 | 28600 | 18000 | 271414 |
| *** TOTAL *** | | | 27940 | 27840 | 37100 | 85023 | 113323 | 117623 | 118720 | 90520 | 77720 | 63600 | 52600 | 232091 | 1044100 |
| MOJAVE WA | TRANMENT=WT083 | 20A | 100 | 80 | 85 | 110 | 120 | 170 | 235 | 175 | 160 | 120 | 60 | 85 | 1500 |
| MOJAVE WA | M GW ENT=WT008 | 22B | 750 | 1140 | 1500 | 1600 | 1630 | 600 | 600 | 600 | 600 | 1530 | 1500 | 1050 | 13100 |
| *** TOTAL *** | | | 850 | 1220 | 1585 | 1710 | 1750 | 770 | 835 | 775 | 760 | 1650 | 1560 | 1135 | 14600 |
| PALMDALE WD | M&I ENT=WT010 | 20B | 1700 | 1150 | 1215 | 1300 | 1903 | 1903 | 1903 | 1903 | 1903 | 1149 | 729 | 542 | 17300 |
| *** TOTAL *** | | | 1700 | 1150 | 1215 | 1300 | 1903 | 1903 | 1903 | 1903 | 1903 | 1149 | 729 | 542 | 17300 |
| SAN BERNARDINO | M&I ENT=WT010 | 26A | 0 | 0 | 500 | 1000 | 1500 | 2200 | 2500 | 2500 | 2500 | 2200 | 1600 | 500 | 17000 |
| SAN BERNARDINO | M GW ENT=WT008 | 26A | 0 | 0 | 500 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 500 | 500 | 500 | 8000 |
| *** TOTAL *** | | | 0 | 0 | 1000 | 2000 | 2500 | 3200 | 3500 | 3500 | 3500 | 2700 | 2100 | 1000 | 25000 |
| SAN GABRIEL | M GW ENT=WT008 | 26A | 0 | 0 | 1778 | 1778 | 1778 | 1778 | 1778 | 1778 | 1778 | 1778 | 1776 | 0 | 16000 |
| SAN GABRIEL | PURPOOLA=WT112 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12800 | 12800 |
| *** TOTAL *** | | | 0 | 0 | 1778 | 1778 | 1778 | 1778 | 1778 | 1778 | 1778 | 1778 | 1776 | 12800 | 28800 |
| SAN GORGONIO | M GW ENT=WT008 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| VENTURA CO FCD | M GW ENT=WT008 | 29H | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 2000 | 5000 |
| VENTURA CO FCD | M&I ENT=WT010 | 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2500 | 2500 | 5000 |
| *** TOTAL *** | | | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3500 | 4500 | 10000 |
| THERMALITO ID | LOCAL =WT024 | FR | 106 | 90 | 94 | 137 | 227 | 321 | 462 | 422 | 309 | 245 | 177 | 90 | 2680 |
| *** TOTAL *** | | | 106 | 90 | 94 | 137 | 227 | 321 | 462 | 422 | 309 | 245 | 177 | 90 | 2680 |
| SHELL CAL PROD. | REPAYMNT=WT009 | 11B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FISH & GAME | REC/F&WL=WT002 | 3 | 20 | 20 | 20 | 50 | 50 | 150 | 200 | 200 | 200 | 50 | 20 | 20 | 1000 |
| FISH & GAME | REC/F&WL=WT002 | 5 | 0 | 0 | 10 | 30 | 40 | 40 | 40 | 30 | 10 | 0 | 0 | 0 | 200 |
| *** TOTAL *** | | | 20 | 20 | 30 | 80 | 90 | 190 | 240 | 230 | 210 | 50 | 20 | 20 | 1200 |
| PARKS & RECREAT | REC/F&WL=WT002 | 3 | 2 | 2 | 3 | 5 | 7 | 6 | 8 | 8 | 8 | 8 | 3 | 2 | 62 |
| *** TOTAL *** | | | 2 | 2 | 3 | 5 | 7 | 6 | 8 | 8 | 8 | 8 | 3 | 2 | 62 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 5SB | 34 | 30 | 34 | 33 | 34 | 33 | 34 | 34 | 33 | 34 | 33 | 34 | 400 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 1 | 5 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 50 |
| USBR (SAN LUIS) | FEDERAL =WT015 | 3A | 4800 | 4200 | 6400 | 8600 | 12400 | 14600 | 15200 | 14600 | 12600 | 7600 | 8500 | 6500 | 116000 |
| USBR (SAN LUIS) | R/F&WLSL=WT078 | 3 | 10 | 10 | 11 | 26 | 28 | 79 | 102 | 102 | 102 | 31 | 12 | 10 | 523 |
| USBR (SAN LUIS) | FEDERAL =WT015 | 3 | 500 | 300 | 700 | 1500 | 2700 | 4200 | 6000 | 5200 | 3100 | 1600 | 500 | 700 | 27000 |
| USBR (SAN LUIS) | FEDERAL =WT015 | 4 | 10860 | 6080 | 12600 | 14560 | 18470 | 33680 | 37810 | 29980 | 6740 | 5870 | 11300 | 29330 | 217280 |
| USBR (SAN LUIS) | R/F&WLSL=WT078 | 5 | 7 | 4 | 7 | 7 | 7 | 10 | 11 | 11 | 9 | 9 | 4 | 4 | 90 |
| USBR (SAN LUIS) | FEDERAL =WT015 | 5 | 35310 | 19770 | 40960 | 47310 | 60020 | 109450 | 122880 | 97450 | 21890 | 19070 | 36720 | 95330 | 706160 |

14112

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COUNTY OF BUTTE TOTAL =      400
          TOT  ENT =      400  M&I  ENT =      400

PLUMAS CO FCWCD TOTAL =      700
          TOT  ENT =      700  M&I  ENT =      700

YUBA CITY       TOTAL =     1575
          TOT  ENT =     1575  M&I  ENT =     1575

NAPA CO FCWCD   TOTAL =     5533
          TOT  ENT =     5533  M&I  ENT =     5533

SOLANO CO WA    TOTAL =    30655
          TOT  ENT =    19355  M&I  ENT =    10485  BEN ENT  =     7420  VAL ENT  =     1450
          TOT MISC =    11300  VAL PMT  =    11300

ZONE-7 ALAMEDA  TOTAL =    38456
          TOT  ENT =    35845  M&I  ENT =    18344  M GW ENT =      720  AGR  ENT =     7436  STOR ENT =     7500  CYOVMENT =      941
                               CYOV ENT =      904
          TOT MISC =     2611  LOCAL     =     2611

ALAMEDA CO WD   TOTAL =    26000
          TOT  ENT =    21000  M&I  ENT =    21000
          TOT MISC =     5000  LOCAL     =     5000

SANTA CLARA VWD TOTAL =    50000
          TOT  ENT =    50000  M&I  ENT =    50000

SAN LUIS OBISPO TOTAL =     3970
          TOT  ENT =     3970  TRANMENT =       50  M&I  ENT =     2799  14B  M&I =     1121

SANTA BARBARA   TOTAL =    19493
          TOT  ENT =    19493  M&I  ENT =    19493

DUDLEY RIDGE WD TOTAL =    29885
          TOT  ENT =    29885  AGR  ENT =    26685  A GW ENT =     3200

EMPIRE WS ID    TOTAL =     4500
          TOT  ENT =     4500  AGR  ENT =     1500  WETAWTHR =     3000

KERN COUNTY WA  TOTAL =   565365
          TOT  ENT =   565365  M&I  ENT =     5650  M GW ENT =    56150  AGR  ENT =   482065  CYOV ENT =    21500

COUNTY OF KINGS TOTAL =     2000
          TOT  ENT =     2000  AGR  ENT =     2000

OAK FLAT WD     TOTAL =     2850
          TOT  ENT =     2850  AGR  ENT =     2850
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TULARE LK BWSD  TOTAL =    59250
            TOT  ENT =    59250  AGR  ENT =    59250

AVEK WA         TOTAL =    35857
            TOT  ENT =    33083  M&I  ENT =    22050  AGR  ENT =    11033
            TOT MISC =     2774  TRANSFER =     2774

CASTAIC LAKE WA TOTAL =    27100
            TOT  ENT =    27100  M&I  ENT =    25300  AGR  ENT =     1800

COACHELLA VALLY TOTAL =    11550
            TOT  ENT =    11550  M&I  ENT =    11550

CRESTLINE-LA WA TOTAL =     1950
            TOT  ENT =     1950  M&I  ENT =     1950

DESERT WA       TOTAL =    11550
            TOT  ENT =    11550  EXCHMENT =    11550

LITTLEROCK CR   TOTAL =     1150
            TOT  ENT =     1150  M&I  ENT =      965  AGR  ENT =      185

METROPOLITAN WD TOTAL = 1197950
            TOT  ENT = 1197950  M&I  ENT =   779750  BYPS ENT =   126000  STOR ENT =    75000  EXMCDENT =   200000  14B  AGR =    17200

MOJAVE WA       TOTAL =     7500
            TOT  ENT =     7500  TRANMENT =     1500  M GW ENT =     6000

PALMDALE WD     TOTAL =     9650
            TOT  ENT =     9650  M&I  ENT =     9650

SAN BERNARDINO  TOTAL =    49800
            TOT  ENT =    49800  M&I  ENT =    22300  M GW ENT =    27500

SAN GABRIEL     TOTAL =    14400
            TOT  ENT =    14400  M GW ENT =    14400

VENTURA CO FCD  TOTAL =     5000
            TOT  ENT =     5000  M&I  ENT =      925  M GW ENT =     4075

FISH & GAME     TOTAL =     1200
            TOT MISC =     1200  REC/F&WL =     1200

PARKS & RECREAT TOTAL =       64
            TOT MISC =       64  REC/F&WL =       64

REC/FISH&WILDLF TOTAL =     7460
            TOT MISC =     7460  REC/F&WL =     7460
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FILE DUMP

FILE IDENTIFICATION: S199898 10/27/99. SHEET 1

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT010 | FR | 18 | 23 | 55 | 158 | 33 | 30 | 13 | 13 | 10 | 10 | 18 | 19 | 400 |
| *** TOTAL *** | | | 18 | 23 | 55 | 158 | 33 | 30 | 13 | 13 | 10 | 10 | 18 | 19 | 400 |
| PLUMAS CO FCWCD | M&I ENT=WT010 | FR | 38 | 38 | 38 | 68 | 75 | 75 | 75 | 75 | 75 | 70 | 38 | 35 | 700 |
| *** TOTAL *** | | | 38 | 38 | 38 | 68 | 75 | 75 | 75 | 75 | 75 | 70 | 38 | 35 | 700 |
| YUBA CITY | M&I ENT=WT010 | FR | 0 | 0 | 0 | 0 | 0 | 250 | 500 | 500 | 250 | 75 | 0 | 0 | 1575 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 250 | 500 | 500 | 250 | 75 | 0 | 0 | 1575 |
| NAPA CO FCWCD | M&I ENT=WT010 | 3NB | 386 | 283 | 319 | 435 | 526 | 567 | 567 | 567 | 547 | 467 | 433 | 436 | 5533 |
| *** TOTAL *** | | | 386 | 283 | 319 | 435 | 526 | 567 | 567 | 567 | 547 | 467 | 433 | 436 | 5533 |
| SOLANO CO WA | M&I ENT=WT010 | 1NB | 200 | 200 | 200 | 200 | 1420 | 1420 | 1420 | 1620 | 1620 | 1185 | 500 | 500 | 10485 |
| SOLANO CO WA | VAL PMT =WT071 | 1NB | 200 | 200 | 200 | 200 | 0 | 25 | 25 | 25 | 25 | 150 | 200 | 200 | 1450 |
| SOLANO CO WA | BEN ENT =WT046 | 3NA | 420 | 500 | 700 | 700 | 700 | 800 | 800 | 800 | 500 | 500 | 500 | 500 | 7420 |
| SOLANO CO WA | VAL ENT =WT047 | 3NA | 0 | 0 | 0 | 0 | 0 | 450 | 500 | 500 | 0 | 0 | 0 | 0 | 1450 |
| SOLANO CO WA | VAL PMT =WT071 | 3NA | 900 | 900 | 900 | 900 | 1000 | 550 | 500 | 500 | 1000 | 900 | 900 | 900 | 9850 |
| *** TOTAL *** | | | 1720 | 1800 | 2000 | 2000 | 3120 | 3245 | 3245 | 3445 | 3145 | 2735 | 2100 | 2100 | 30655 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 1SB | 0 | 5 | 11 | 25 | 34 | 39 | 43 | 45 | 42 | 35 | 20 | 6 | 305 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 1SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 1SB | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| ZONE-7 ALAMEDA | CYOVMENT=WT077 | 2SB | 490 | 451 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 941 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 2SB | 0 | 0 | 0 | 0 | 251 | 559 | 1140 | 1140 | 1135 | 954 | 638 | 530 | 6347 |
| ZONE-7 ALAMEDA | STOR ENT=WT060 | 2SB | 0 | 8 | 551 | 725 | 708 | 511 | 0 | 0 | 0 | 0 | 0 | 0 | 2503 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 2SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 4SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 4SB | 0 | 115 | 455 | 482 | 541 | 606 | 614 | 598 | 563 | 455 | 327 | 89 | 4845 |
| ZONE-7 ALAMEDA | CYOV ENT=WT069 | 4SB | 64 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 64 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 5SB | 180 | 180 | 180 | 180 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 720 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 5SB | 0 | 40 | 90 | 90 | 90 | 90 | 90 | 90 | 90 | 70 | 40 | 10 | 790 |
| ZONE-7 ALAMEDA | CYOV ENT=WT069 | 5SB | 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| ZONE-7 ALAMEDA | GEN WLNG=WT079 | 6SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 6SB | 0 | 0 | 0 | 330 | 351 | 521 | 2073 | 2120 | 2095 | 1866 | 1275 | 1061 | 11692 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 6SB | 0 | 72 | 119 | 175 | 232 | 256 | 281 | 247 | 192 | 144 | 64 | 19 | 1801 |
| ZONE-7 ALAMEDA | STOR ENT=WT060 | 6SB | 0 | 749 | 933 | 1020 | 1125 | 1170 | 0 | 0 | 0 | 0 | 0 | 0 | 4997 |
| ZONE-7 ALAMEDA | CYOV ENT=WT069 | 6SB | 830 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 830 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 6SB | 170 | 170 | 170 | 100 | 443 | 453 | 483 | 404 | 175 | 42 | 0 | 0 | 2610 |
| *** TOTAL *** | | | 1745 | 1790 | 2509 | 3127 | 3775 | 4205 | 4724 | 4644 | 4292 | 3566 | 2364 | 1715 | 38456 |
| ALAMEDA CO WD | M GW ENT=WT008 | 7SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ALAMEDA CO WD | LOCAL =WT024 | 7SB | 485 | 438 | 485 | 470 | 485 | 470 | 485 | 485 | 470 | 727 | 0 | 0 | 5000 |
| ALAMEDA CO WD | M&I ENT=WT010 | 8SB | 1664 | 1503 | 1664 | 1611 | 1664 | 1611 | 1664 | 1664 | 1611 | 2138 | 2069 | 2137 | 21000 |
| *** TOTAL *** | | | 2149 | 1941 | 2149 | 2081 | 2149 | 2081 | 2149 | 2149 | 2081 | 2865 | 2069 | 2137 | 26000 |
| SANTA CLARA VWD | M&I ENT=WT010 | 9SB | 2200 | 2100 | 2700 | 4065 | 5230 | 5340 | 5500 | 5500 | 5300 | 5265 | 4150 | 2650 | 50000 |
| SAN LUIS OBISPO | TRANMENT=WT083 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 50 |
| SAN LUIS OBISPO | M&I ENT=WT010 | 34 | 0 | 0 | 0 | 210 | 266 | 370 | 424 | 429 | 377 | 259 | 247 | 217 | 2799 |
| | | | | | | | | | | | | | | | 1121 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SANTA CLARA VWD | M&I ENT=WT010 | 9SB | 2200 | 2100 | 2700 | 4065 | 5230 | 5340 | 5500 | 5500 | 5300 | 5265 | 4150 | 2650 | 50000 |
| *** TOTAL *** | | | 2200 | 2100 | 2700 | 4065 | 5230 | 5340 | 5500 | 5500 | 5300 | 5265 | 4150 | 2650 | 50000 |

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SAN LUIS OBISPO | TRANMENT=WT083 | 34 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 50 | 0 | 0 | 0 | 50 |
| SAN LUIS OBISPO | M&I ENT=WT010 | 34 | 0 | 0 | 0 | 210 | 266 | 370 | 424 | 429 | 377 | 259 | 247 | 217 | 2799 |
| SAN LUIS OBISPO | 14B M&I=WT043 | 34 | 374 | 373 | 374 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1121 |
| *** TOTAL *** | | | 374 | 373 | 374 | 210 | 266 | 370 | 424 | 429 | 427 | 259 | 247 | 217 | 3970 |
| SANTA BARBARA | M&I ENT=WT010 | 33A | 1093 | 1016 | 1213 | 1611 | 1813 | 2189 | 2299 | 2123 | 1963 | 1595 | 1368 | 1210 | 19493 |
| *** TOTAL *** | | | 1093 | 1016 | 1213 | 1611 | 1813 | 2189 | 2299 | 2123 | 1963 | 1595 | 1368 | 1210 | 19493 |
| DUDLEY RIDGE WD | AGR ENT=WT001 | 8D | 200 | 1500 | 1600 | 1900 | 2300 | 4600 | 5700 | 5600 | 1700 | 800 | 785 | 0 | 26685 |
| DUDLEY RIDGE WD | A GW ENT=WT022 | 8D | 1600 | 1600 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3200 |
| *** TOTAL *** | | | 1800 | 3100 | 1600 | 1900 | 2300 | 4600 | 5700 | 5600 | 1700 | 800 | 785 | 0 | 29885 |
| EMPIRE WS ID | AGR ENT=WT001 | 8C | 400 | 400 | 400 | 0 | 100 | 100 | 100 | 0 | 0 | 0 | 0 | 0 | 1500 |
| EMPIRE WS ID | WETAWTHR=WT007 | 8C | 100 | 100 | 100 | 200 | 100 | 500 | 500 | 500 | 200 | 100 | 300 | 300 | 3000 |
| *** TOTAL *** | | | 500 | 500 | 500 | 200 | 200 | 600 | 600 | 500 | 200 | 100 | 300 | 300 | 4500 |
| KERN COUNTY WA | AGR ENT=WT001 | 9 | 610 | 610 | 2420 | 3020 | 4220 | 7230 | 12030 | 7230 | 1220 | 620 | 620 | 353 | 40183 |
| KERN COUNTY WA | CYOV ENT=WT069 | 9 | 300 | 300 | 2500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3100 |
| KERN COUNTY WA | EXACOENT=WT115 | 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M&I ENT=WT010 | 10A | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 500 |
| KERN COUNTY WA | AGR ENT=WT001 | 10A | 550 | 700 | 2200 | 2600 | 15050 | 27000 | 37300 | 27300 | 1100 | 550 | 475 | 297 | 115122 |
| KERN COUNTY WA | CYOV ENT=WT069 | 10A | 450 | 950 | 1000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2400 |
| KERN COUNTY WA | X82 ORO=WT051 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M&I ENT=WT010 | 11B | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 166 | 166 | 166 | 166 | 167 | 2000 |
| KERN COUNTY WA | AGR ENT=WT001 | 11B | 1267 | 2533 | 5067 | 5067 | 6333 | 10133 | 16200 | 12667 | 2533 | 1266 | 633 | 634 | 64333 |
| KERN COUNTY WA | CYOV ENT=WT069 | 11B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M&I ENT=WT010 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M GW ENT=WT008 | 12E | 0 | 0 | 0 | 0 | 2250 | 15900 | 18050 | 14817 | 3133 | 1000 | 500 | 500 | 56150 |
| KERN COUNTY WA | AGR ENT=WT001 | 12E | 0 | 0 | 0 | 950 | 5250 | 15650 | 18300 | 14100 | 223 | 0 | 800 | 760 | 56033 |
| KERN COUNTY WA | CYOV ENT=WT069 | 12E | 1000 | 3000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4000 |
| KERN COUNTY WA | 78MWD 30=WT016 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | X82 ORO=WT051 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | X82 MWD=WT052 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | EXACOENT=WT115 | 12E | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M GW ENT=WT008 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | AGR ENT=WT001 | 13B | 0 | 0 | 0 | 0 | 1000 | 6000 | 7750 | 5650 | 0 | 0 | 0 | 0 | 20400 |
| KERN COUNTY WA | CYOV ENT=WT069 | 13B | 1000 | 3000 | 1000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5000 |
| KERN COUNTY WA | X82 ORO=WT051 | 13B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M&I ENT=WT010 | 14A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | AGR ENT=WT001 | 14A | 500 | 750 | 1000 | 1200 | 1150 | 3640 | 4290 | 3055 | 975 | 150 | 100 | 100 | 16910 |
| KERN COUNTY WA | CYOV ENT=WT069 | 14A | 300 | 400 | 600 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1300 |
| KERN COUNTY WA | AGR ENT=WT001 | 14B | 1700 | 2000 | 3800 | 2700 | 3750 | 10400 | 11440 | 7719 | 1755 | 1000 | 650 | 650 | 47564 |
| KERN COUNTY WA | CYOV ENT=WT069 | 14B | 850 | 1000 | 1200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3050 |
| KERN COUNTY WA | AGR ENT=WT001 | 14C | 750 | 1250 | 900 | 1500 | 2150 | 4355 | 4875 | 3640 | 1495 | 550 | 350 | 350 | 22165 |
| KERN COUNTY WA | CYOV ENT=WT069 | 14C | 400 | 500 | 750 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1650 |
| KERN COUNTY WA | AGR ENT=WT001 | 15A | 400 | 800 | 1250 | 1750 | 2450 | 4160 | 4095 | 3185 | 1625 | 1500 | 1150 | 1150 | 23515 |
| KERN COUNTY WA | CYOV ENT=WT069 | 15A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M&I ENT=WT010 | 16A | 0 | 0 | 0 | 725 | 725 | 740 | 558 | 402 | 0 | 0 | 0 | 0 | 3150 |
| KERN COUNTY WA | AGR ENT=WT001 | 16A | 150 | 200 | 300 | 850 | 1490 | 1915 | 2229 | 1527 | 1329 | 550 | 250 | 250 | 11040 |
| KERN COUNTY WA | CYOV ENT=WT069 | 16A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | EXACOENT=WT115 | 16A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| KERN COUNTY WA | M GW ENT=WT008 | 31A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

FILE DUMP

FILE IDENTIFICATION: S199898 10/27/99. SHEET 3

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KERN COUNTY WA | AGR ENT=WT001 | 31A | 1000 | 1500 | 2500 | 4600 | 8900 | 12000 | 11900 | 11400 | 5000 | 3000 | 2000 | 1000 | 64800 |
| KERN COUNTY WA | CYOV ENT=WT069 | 31A | 1000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 |
| *** TOTAL *** | | | 12419 | 19685 | 26704 | 25179 | 54935 | 119340 | 149234 | 112908 | 20604 | 10402 | 7719 | 6236 | 565365 |
| COUNTY OF KINGS | AGR ENT=WT001 | 8C | 0 | 0 | 0 | 0 | 0 | 400 | 400 | 400 | 0 | 0 | 400 | 400 | 2000 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 400 | 400 | 400 | 0 | 0 | 400 | 400 | 2000 |
| OAK FLAT WD | AGR ENT=WT001 | 2A | 57 | 86 | 171 | 228 | 285 | 456 | 513 | 513 | 257 | 114 | 86 | 84 | 2850 |
| *** TOTAL *** | | | 57 | 86 | 171 | 228 | 285 | 456 | 513 | 513 | 257 | 114 | 86 | 84 | 2850 |
| TULARE LK BWSD | AGR ENT=WT001 | 8C | 0 | 0 | 0 | 800 | 560 | 5080 | 5800 | 5760 | 80 | 200 | 1200 | 4220 | 23700 |
| TULARE LK BWSD | AGR ENT=WT001 | 8D | 0 | 0 | 0 | 1200 | 840 | 7620 | 8700 | 8640 | 120 | 300 | 1800 | 6330 | 35550 |
| *** TOTAL *** | | | 0 | 0 | 0 | 2000 | 1400 | 12700 | 14500 | 14400 | 200 | 500 | 3000 | 10550 | 59250 |
| AVEK WA | AGR ENT=WT001 | 19 | 38 | 38 | 52 | 112 | 122 | 80 | 107 | 87 | 120 | 110 | 90 | 57 | 1013 |
| AVEK WA | M&I ENT=WT010 | 19C | 117 | 132 | 171 | 249 | 300 | 367 | 393 | 415 | 355 | 288 | 196 | 157 | 3140 |
| AVEK WA | AGR ENT=WT001 | 19C | 25 | 242 | 870 | 906 | 1084 | 1402 | 1603 | 1512 | 1104 | 520 | 95 | 11 | 9374 |
| AVEK WA | TRANSFER=WT067 | 19C | 60 | 23 | 79 | 223 | 318 | 345 | 355 | 352 | 333 | 311 | 90 | 41 | 2530 |
| AVEK WA | M&I ENT=WT010 | 20A | 691 | 538 | 946 | 1338 | 1711 | 2200 | 2117 | 2253 | 2027 | 1361 | 933 | 805 | 16920 |
| AVEK WA | AGR ENT=WT001 | 20A | 5 | 5 | 5 | 7 | 7 | 7 | 7 | 7 | 7 | 6 | 5 | 5 | 73 |
| AVEK WA | TRANSFER=WT067 | 20A | 7 | 9 | 20 | 19 | 24 | 24 | 30 | 35 | 37 | 20 | 10 | 9 | 244 |
| AVEK WA | M&I ENT=WT010 | 20B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AVEK WA | M&I ENT=WT010 | 22A | 77 | 64 | 109 | 158 | 200 | 279 | 254 | 248 | 263 | 163 | 92 | 83 | 1990 |
| AVEK WA | AGR ENT=WT001 | 22A | 0 | 8 | 56 | 56 | 74 | 64 | 81 | 80 | 77 | 50 | 25 | 2 | 573 |
| *** TOTAL *** | | | 1020 | 1059 | 2308 | 3068 | 3840 | 4768 | 4947 | 4989 | 4323 | 2829 | 1536 | 1170 | 35857 |
| CASTAIC LAKE WA | M&I ENT=WT010 | 30 | 1012 | 1012 | 1265 | 1771 | 2530 | 3036 | 3542 | 3542 | 3289 | 2277 | 1012 | 1012 | 25300 |
| CASTAIC LAKE WA | AGR ENT=WT001 | 31A | 108 | 162 | 162 | 162 | 162 | 162 | 252 | 270 | 72 | 0 | 162 | 126 | 1800 |
| *** TOTAL *** | | | 1120 | 1174 | 1427 | 1933 | 2692 | 3198 | 3794 | 3812 | 3361 | 2277 | 1174 | 1138 | 27100 |
| COACHELLA VALLEY | M&I ENT=WT010 | 26A | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 968 | 11550 |
| *** TOTAL *** | | | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 962 | 968 | 11550 |
| CRESTLINE-LA WA | M&I ENT=WT010 | 24 | 95 | 61 | 52 | 111 | 152 | 164 | 242 | 253 | 232 | 198 | 200 | 190 | 1950 |
| *** TOTAL *** | | | 95 | 61 | 52 | 111 | 152 | 164 | 242 | 253 | 232 | 198 | 200 | 190 | 1950 |
| DESERT WA | EXCHMENT=WT099 | 26A | 0 | 0 | 0 | 3850 | 3850 | 3850 | 0 | 0 | 0 | 0 | 0 | 0 | 11550 |
| *** TOTAL *** | | | 0 | 0 | 0 | 3850 | 3850 | 3850 | 0 | 0 | 0 | 0 | 0 | 0 | 11550 |
| LITTLEROCK CR | M&I ENT=WT010 | 21 | 30 | 30 | 65 | 75 | 100 | 120 | 140 | 140 | 120 | 75 | 40 | 30 | 965 |
| LITTLEROCK CR | AGR ENT=WT001 | 21 | 0 | 0 | 15 | 20 | 25 | 30 | 30 | 30 | 20 | 15 | 0 | 0 | 185 |
| *** TOTAL *** | | | 30 | 30 | 80 | 95 | 125 | 150 | 170 | 170 | 140 | 90 | 40 | 30 | 1150 |
| METROPOLITAN WD | EXMCOENT=WT116 | 3A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200000 | 200000 |
| METROPOLITAN WD | STOR ENT=WT060 | 10A | 0 | 0 | 0 | 0 | 25000 | 25000 | 25000 | 0 | 0 | 0 | 0 | 0 | 75000 |
| METROPOLITAN WD | M&I ENT=WT010 | 26A | 9000 | 7000 | 7000 | 41150 | 36150 | 40150 | 31650 | 51650 | 34650 | 28000 | 22000 | 12000 | 320400 |

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METROPOLITAN WD | 78 EX GW=WT037 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| METROPOLITAN WD | -78EX GW=WT038 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| METROPOLITAN WD | X82 GW=WT054 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| METROPOLITAN WD | -X82 GW=WT055 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| METROPOLITAN WD | M&I ENT=WT010 | 28H | 4000 | 3000 | 4000 | 5000 | 6000 | 7000 | 8000 | 9000 | 8000 | 6000 | 5000 | 5000 | 70000 |
| METROPOLITAN WD | BYPS ENT=WT059 | 28H | 0 | 0 | 0 | 20000 | 19000 | 21000 | 23000 | 21000 | 22000 | 0 | 0 | 0 | 126000 |
| METROPOLITAN WD | M&I ENT=WT010 | 28J | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 3600 |
| METROPOLITAN WD | M&I ENT=WT010 | 30 | 30000 | 39000 | 46000 | 17200 | 24000 | 26000 | 29500 | 28050 | 26000 | 40000 | 44000 | 36000 | 385750 |
| METROPOLITAN WD | 14B AGR=WT014 | 30 | 0 | 0 | 0 | 17200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17200 |
| | *** TOTAL *** | | 43300 | 49300 | 57300 | 100850 | 110450 | 119450 | 117450 | 110000 | 90950 | 74300 | 71300 | 253300 | 1197950 |
| MOJAVE WA | TRANMENT=WT083 | 22B | 100 | 80 | 85 | 110 | 120 | 170 | 235 | 175 | 160 | 120 | 60 | 85 | 1500 |
| MOJAVE WA | M GW ENT=WT008 | 22B | 325 | 530 | 708 | 745 | 755 | 265 | 233 | 263 | 270 | 705 | 720 | 481 | 6000 |
| | *** TOTAL *** | | 425 | 610 | 793 | 855 | 875 | 435 | 468 | 438 | 430 | 825 | 780 | 566 | 7500 |
| PALMDALE WD | M&I ENT=WT010 | 20B | 1000 | 0 | 0 | 0 | 300 | 600 | 2903 | 1903 | 1100 | 800 | 600 | 444 | 9650 |
| | *** TOTAL *** | | 1000 | 0 | 0 | 0 | 300 | 600 | 2903 | 1903 | 1100 | 800 | 600 | 444 | 9650 |
| SAN BERNARDINO | M&I ENT=WT010 | 26A | 500 | 500 | 700 | 1500 | 2000 | 2700 | 3100 | 3100 | 3100 | 2600 | 1800 | 700 | 22300 |
| SAN BERNARDINO | M GW ENT=WT008 | 26A | 500 | 500 | 500 | 1000 | 4000 | 5000 | 5000 | 5000 | 4000 | 1000 | 500 | 500 | 27500 |
| | *** TOTAL *** | | 1000 | 1000 | 1200 | 2500 | 6000 | 7700 | 8100 | 8100 | 7100 | 3600 | 2300 | 1200 | 49800 |
| SAN GABRIEL | M GW ENT=WT008 | 26A | 0 | 0 | 0 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 0 | 0 | 0 | 14400 |
| SAN GABRIEL | PURPOOLA=WT112 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | *** TOTAL *** | | 0 | 0 | 0 | 2400 | 2400 | 2400 | 2400 | 2400 | 2400 | 0 | 0 | 0 | 14400 |
| SAN GORGONIO | M GW ENT=WT008 | 26A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | *** TOTAL *** | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| VENTURA CO FCD | M GW ENT=WT008 | 29F | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1575 | 0 | 0 | 0 | 1575 |
| VENTURA CO FCD | M GW ENT=WT008 | 29H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1250 | 1250 | 2500 |
| VENTURA CO FCD | M&I ENT=WT010 | 30 | 77 | 77 | 77 | 77 | 77 | 77 | 78 | 77 | 77 | 77 | 77 | 77 | 925 |
| | *** TOTAL *** | | 77 | 77 | 77 | 77 | 77 | 77 | 78 | 77 | 1652 | 77 | 1327 | 1327 | 5000 |
| SHELL CAL PROD. | REPAYMNT=WT009 | 11B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | *** TOTAL *** | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FISH & GAME | REC/F&WL=WT002 | 3 | 20 | 20 | 20 | 50 | 50 | 150 | 200 | 200 | 200 | 50 | 20 | 20 | 1000 |
| FISH & GAME | REC/F&WL=WT002 | 5 | 0 | 0 | 10 | 30 | 40 | 40 | 40 | 30 | 10 | 0 | 0 | 0 | 200 |
| | *** TOTAL *** | | 20 | 20 | 30 | 80 | 90 | 190 | 240 | 230 | 210 | 50 | 20 | 20 | 1200 |
| PARKS & RECREAT | REC/F&WL=WT002 | 3 | 2 | 2 | 3 | 4 | 6 | 7 | 8 | 9 | 8 | 8 | 4 | 3 | 64 |
| | *** TOTAL *** | | 2 | 2 | 3 | 4 | 6 | 7 | 8 | 9 | 8 | 8 | 4 | 3 | 64 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 5SB | 34 | 30 | 34 | 33 | 34 | 33 | 34 | 34 | 33 | 34 | 33 | 34 | 400 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 1 | 5 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 50 |

FILE ID: U199999

DATE: 10/26/99
PAGE: 1

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--------------------------------
COUNTY OF BUTTE TOTAL =     2890
            TOT  ENT =      800  M&I  ENT =      800
            TOT MISC =     2090  ANTTRNBK =     2090
--------------------------------
PLUMAS CO FCWCD TOTAL =      363
            TOT  ENT =      363  M&I  ENT =      363
--------------------------------
YUBA CITY       TOTAL =     9600
            TOT  ENT =     2400  M&I  ENT =     2400
            TOT MISC =     7200  ANTTRNBK =     7200
--------------------------------
NAPA CO-FCWCD   TOTAL =    15850
            TOT  ENT =    15850  M&I  ENT =    15850
--------------------------------
SOLANO CO WA    TOTAL =    50570
            TOT  ENT =    39170  M&I  ENT =    14000  BEN ENT  =    15170  VAL ENT  =     2900  ANTEXMCO =     7100
            TOT MISC =    11400  VAL PMT  =    11400
--------------------------------
ZONE-7 ALAMEDA  TOTAL =    61494
            TOT  ENT =    46000  M&I  ENT =    22508  M GW ENT =     8242  AGR  ENT =     6580  STOR ENT =     8670
            TOT MISC =    15494  GEN WLNG =     1000  LOCAL     =    14494
--------------------------------
ALAMEDA CO WD   TOTAL =    48000
            TOT  ENT =    42000  M&I  ENT =    30763  M GW ENT =     3737  STOR ENT =     7500
            TOT MISC =     6000  LOCAL     =     6000
--------------------------------
SANTA CLARA VWD TOTAL =   100000
            TOT  ENT =   100000  M&I  ENT =    60750  M GW ENT =     9250  STOR ENT =    10000  ANTEXMCO =    20000
--------------------------------
SAN LUIS OBISPO TOTAL =    25000
            TOT  ENT =     7126  M&I  ENT =     7126
            TOT MISC =    17874  ANTTRNBK =    17874
--------------------------------
SANTA BARBARA   TOTAL =    45486
            TOT  ENT =    31115  M&I  ENT =    31115
            TOT MISC =    14371  ANTTRNBK =    14371
--------------------------------
DUDLEY RIDGE WD TOTAL =    53370
            TOT  ENT =    53370  AGR  ENT =    51370  A GW ENT =     2000
--------------------------------
EMPIRE WS ID    TOTAL =     6000
            TOT  ENT =     6000  AGR  ENT =     3000  WETAWTHR =     3000
--------------------------------
KERN COUNTY WA  TOTAL =  1184730
            TOT  ENT =  1184730  M&I  ENT =     6900  M GW ENT =   112700  AGR  ENT =   965130  EXCHMENT =     2000  EXACDENT =    97000
                                 ANTEXACD =     1000
--------------------------------
COUNTY OF KINGS TOTAL =     5000
            TOT  ENT =     5000  AGR  ENT =     4000  CYOV ENT =     1000
```

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| OAK FLAT WD | TOTAL = | 6150 | | | | | | | | | |
| | TOT ENT = | 6150 | AGR ENT = | 5700 | CYOV ENT = | 450 | | | | | |
| TULARE LK BWSD | TOTAL = | 162500 | | | | | | | | | |
| | TOT ENT = | 162500 | AGR ENT = | 118500 | CYOV ENT = | 44000 | | | | | |
| AVEK WA | TOTAL = | 141900 | | | | | | | | | |
| | TOT ENT = | 72918 | M&I ENT = | 47718 | AGR ENT = | 25200 | | | | | |
| | TOT MISC = | 68982 | TRANSFER = | 1500 | EXCHANGE = | 2000 | ANTTRNBK = | 65482 | | | |
| CASTAIC LAKE WA | TOTAL = | 54200 | | | | | | | | | |
| | TOT ENT = | 37700 | M&I ENT = | 25000 | AGR ENT = | 12700 | | | | | |
| | TOT MISC = | 16500 | ANTTRNBK = | 16500 | | | | | | | |
| COACHELLA VALLY | TOTAL = | 23100 | | | | | | | | | |
| | TOT ENT = | 23100 | M&I ENT = | 23100 | | | | | | | |
| CRESTLINE-LA WA | TOTAL = | 5800 | | | | | | | | | |
| | TOT ENT = | 1950 | M&I ENT = | 1950 | | | | | | | |
| | TOT MISC = | 3850 | ANTTRNBK = | 3850 | | | | | | | |
| DESERT WA | TOTAL = | 38100 | | | | | | | | | |
| | TOT ENT = | 38100 | M GW ENT = | 38100 | | | | | | | |
| LITTLEROCK CR | TOTAL = | 2300 | | | | | | | | | |
| | TOT ENT = | 2300 | M&I ENT = | 1930 | AGR ENT = | 370 | | | | | |
| METROPOLITAN WD | TOTAL = | 1380000 | | | | | | | | | |
| | TOT ENT = | 1380000 | M&I ENT = | 592978 | BYPS ENT = | 233022 | STOR ENT = | 154000 | EXMCOENT = | 200000 | ANTEXMCO = 200000 |
| MOJAVE WA | TOTAL = | 20000 | | | | | | | | | |
| | TOT ENT = | 20000 | TRANMENT = | 1500 | M GW ENT = | 18500 | | | | | |
| PALMDALE WD | TOTAL = | 22300 | | | | | | | | | |
| | TOT ENT = | 22300 | M&I ENT = | 12300 | EXMCOENT = | 5000 | ANTEXMCO = | 5000 | | | |
| SAN BERNARDINO | TOTAL = | 102600 | | | | | | | | | |
| | TOT ENT = | 102600 | M&I ENT = | 39600 | M GW ENT = | 63000 | | | | | |
| SAN GABRIEL | TOTAL = | 28800 | | | | | | | | | |
| | TOT ENT = | 18000 | M GW ENT = | 18000 | | | | | | | |
| | TOT MISC = | 10800 | ANTTRNBK = | 10800 | | | | | | | |
| VENTURA CO FCD | TOTAL = | 2050 | | | | | | | | | |
| | TOT ENT = | 2050 | M&I ENT = | 1850 | M GW ENT = | 200 | | | | | |
| FISH & GAME | TOTAL = | 1200 | | | | | | | | | |
| | TOT MISC = | 1200 | REC/F&WL = | 1200 | | | | | | | |

FILE DUMP

FILE IDENTIFICATION: U199999 10/26/99. SHEET 1

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT010 | FR | 35 | 45 | 110 | 315 | 65 | 60 | 25 | 25 | 20 | 20 | 35 | 45 | 800 |
| COUNTY OF BUTTE | ANTTRNBK=WT133 | FR | 172 | 173 | 172 | 173 | 172 | 173 | 172 | 172 | 173 | 172 | 173 | 193 | 2090 |
| *** TOTAL *** | | | 207 | 218 | 282 | 488 | 237 | 233 | 197 | 197 | 193 | 192 | 208 | 238 | 2890 |
| PLUMAS CO FCWCD | M&I ENT=WT010 | FR | 10 | 10 | 10 | 10 | 10 | 67 | 75 | 75 | 66 | 10 | 10 | 10 | 363 |
| *** TOTAL *** | | | 10 | 10 | 10 | 10 | 10 | 67 | 75 | 75 | 66 | 10 | 10 | 10 | 363 |
| YUBA CITY | M&I ENT=WT010 | FR | 0 | 0 | 0 | 0 | 0 | 300 | 900 | 900 | 300 | 0 | 0 | 0 | 2400 |
| YUBA CITY | ANTTRNBK=WT133 | FR | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 7200 |
| *** TOTAL *** | | | 600 | 600 | 600 | 600 | 600 | 900 | 1500 | 1500 | 900 | 600 | 600 | 600 | 9600 |
| NAPA CO FCWCD | M&I ENT=WT010 | 3NB | 900 | 940 | 1200 | 1235 | 1490 | 1630 | 1605 | 1755 | 1605 | 1440 | 1080 | 970 | 15850 |
| *** TOTAL *** | | | 900 | 940 | 1200 | 1235 | 1490 | 1630 | 1605 | 1755 | 1605 | 1440 | 1080 | 970 | 15850 |
| SOLANO CO WA | M&I ENT=WT010 | 1NB | 450 | 450 | 475 | 1070 | 1420 | 1420 | 1420 | 1620 | 1620 | 1420 | 1370 | 1265 | 14000 |
| SOLANO CO WA | VAL PMT =WT071 | 1NB | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 100 |
| SOLANO CO WA | ANTEXMCO=WT131 | 1NB | 592 | 592 | 592 | 592 | 592 | 592 | 592 | 592 | 592 | 592 | 592 | 588 | 7100 |
| SOLANO CO WA | BEN ENT =WT046 | 3NA | 955 | 955 | 970 | 1225 | 1380 | 1560 | 1660 | 1660 | 1315 | 1300 | 1200 | 990 | 15170 |
| SOLANO CO WA | VAL ENT =WT047 | 3NA | 0 | 0 | 0 | 0 | 0 | 500 | 500 | 500 | 500 | 500 | 400 | 0 | 2900 |
| SOLANO CO WA | VAL PMT =WT071 | 3NA | 900 | 900 | 900 | 900 | 1000 | 1000 | 1000 | 1000 | 1000 | 900 | 900 | 900 | 11300 |
| *** TOTAL *** | | | 2897 | 2897 | 2937 | 3787 | 4392 | 5097 | 5197 | 5397 | 5052 | 4712 | 4462 | 3743 | 50570 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 1SB | 3 | 2 | 5 | 13 | 26 | 33 | 37 | 39 | 36 | 27 | 11 | 3 | 235 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 2SB | 0 | 0 | 0 | 70 | 834 | 1211 | 1456 | 1455 | 1252 | 1044 | 688 | 434 | 8444 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 2SB | 526 | 492 | 618 | 740 | 240 | 60 | 0 | 0 | 0 | 0 | 0 | 134 | 2810 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 4SB | 0 | 0 | 0 | 1120 | 1170 | 1130 | 1170 | 1170 | 1170 | 232 | 0 | 0 | 7162 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 4SB | 37 | 145 | 227 | 360 | 586 | 612 | 611 | 590 | 333 | 302 | 146 | 37 | 3986 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 4SB | 850 | 770 | 850 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2470 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 5SB | 0 | 0 | 0 | 180 | 180 | 180 | 180 | 180 | 180 | 0 | 0 | 0 | 1080 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 5SB | 10 | 10 | 30 | 70 | 100 | 110 | 140 | 120 | 90 | 60 | 40 | 20 | 800 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 5SB | 180 | 180 | 180 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 540 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 6SB | 1002 | 900 | 1120 | 0 | 0 | 0 | 2191 | 2900 | 2503 | 2077 | 1136 | 0 | 13829 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 6SB | 10 | 56 | 99 | 171 | 234 | 276 | 302 | 262 | 186 | 126 | 62 | 10 | 1794 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 6SB | 49 | 84 | 115 | 1620 | 2149 | 2541 | 720 | 10 | 0 | 10 | 240 | 1136 | 8674 |
| ZONE-7 ALAMEDA | GEN WLNG=WT079 | 10A | 0 | 500 | 500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 |
| ZONE-7 ALAMEDA | STOR ENT=WT060 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8670 | 0 | 0 | 0 | 0 | 8670 |
| *** TOTAL *** | | | 2667 | 3139 | 3744 | 4344 | 5519 | 6153 | 6807 | 15396 | 5750 | 3878 | 2323 | 1774 | 61494 |
| ALAMEDA CO WD | M GW ENT=WT008 | 7SB | 0 | 0 | 0 | 0 | 237 | 750 | 750 | 750 | 750 | 500 | 0 | 0 | 3737 |
| ALAMEDA CO WD | LOCAL =WT024 | 7SB | 0 | 0 | 0 | 0 | 0 | 1500 | 1500 | 1500 | 1500 | 0 | 0 | 0 | 6000 |
| ALAMEDA CO WD | M&I ENT=WT010 | 8SB | 2613 | 2360 | 2613 | 2528 | 2613 | 2528 | 2613 | 2613 | 2528 | 2613 | 2528 | 2613 | 30763 |
| ALAMEDA CO WD | STOR ENT=WT060 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 3750 | 3750 | 0 | 0 | 0 | 0 | 7500 |
| *** TOTAL *** | | | 2613 | 2360 | 2613 | 2528 | 2850 | 4778 | 8613 | 8613 | 4778 | 3113 | 2528 | 2613 | 48000 |
| SANTA CLARA VWD | M&I ENT=WT010 | 9SB | 1750 | 1700 | 1800 | 4500 | 5000 | 6000 | 8000 | 8000 | 8000 | 7000 | 5000 | 4000 | 60750 |
| SANTA CLARA VWD | M GW ENT=WT008 | 9SB | 0 | 0 | 900 | 1000 | 1200 | 1200 | 1200 | 1200 | 1000 | 1000 | 550 | 0 | 9250 |
| SANTA CLARA VWD | ANTEXMCO=WT131 | 9SB | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1663 | 20000 |
| SANTA CLARA VWD | STOR ENT=WT060 | 10A | 0 | 0 | 0 | 0 | 0 | 10000 | 0 | 0 | 0 | 0 | 0 | 0 | 10000 |
| *** TOTAL *** | | | 3417 | 3367 | 4367 | 7167 | 7867 | 18867 | 10867 | 10867 | 10667 | 9667 | 7217 | 5663 | 100000 |

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SANTA CLARA VWD | ANTEXMCO=WT131 | 9SB | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1667 | 1663 | 20000 |
| SANTA CLARA VWD | STOR ENT=WT060 | 10A | 0 | 0 | 0 | 0 | 0 | 10000 | 0 | 0 | 0 | 0 | 0 | 0 | 10000 |
| SAN LUIS OBISPO | M&I ENT=WT010 | 33A | 474 | 418 | 484 | 544 | 622 | 692 | 772 | 796 | 690 | 613 | 545 | 476 | 7126 |
| SAN LUIS OBISPO | ANTTRNBK=WT133 | 33A | 1490 | 1490 | 1490 | 1490 | 1490 | 1490 | 1490 | 1490 | 1490 | 1490 | 1490 | 1484 | 17874 |
| *** TOTAL *** | | | 1964 | 1908 | 1974 | 2034 | 2112 | 2182 | 2262 | 2286 | 2180 | 2103 | 2035 | 1960 | 25000 |
| SANTA BARBARA | M&I ENT=WT010 | 33A | 1965 | 1794 | 2133 | 2548 | 3083 | 3139 | 3283 | 3232 | 2962 | 2643 | 2272 | 2061 | 31115 |
| SANTA BARBARA | ANTTRNBK=WT133 | 33A | 1198 | 1198 | 1198 | 1198 | 1198 | 1198 | 1198 | 1198 | 1198 | 1198 | 1198 | 1193 | 14371 |
| *** TOTAL *** | | | 3163 | 2992 | 3331 | 3746 | 4281 | 4337 | 4481 | 4430 | 4160 | 3841 | 3470 | 3254 | 45486 |
| DUDLEY RIDGE WD | AGR ENT=WT001 | 8D | 400 | 3000 | 3100 | 3600 | 4400 | 8800 | 10900 | 10700 | 3300 | 1500 | 1600 | 70 | 51370 |
| DUDLEY RIDGE WD | A GW ENT=WT022 | 8D | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2000 | 2000 |
| *** TOTAL *** | | | 400 | 3000 | 3100 | 3600 | 4400 | 8800 | 10900 | 10700 | 3300 | 1500 | 1600 | 2070 | 53370 |
| EMPIRE WS ID | AGR ENT=WT001 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | WETAWTHR=WT007 | 8C | 400 | 400 | 400 | 0 | 100 | 500 | 500 | 500 | 200 | 0 | 0 | 0 | 3000 |
| *** TOTAL *** | | | 460 | 490 | 580 | 240 | 400 | 980 | 1040 | 1040 | 470 | 120 | 90 | 90 | 6000 |
| KERN COUNTY WA | AGR ENT=WT001 | 9 | 600 | 600 | 4800 | 7200 | 9000 | 14400 | 20400 | 14400 | 2400 | 1200 | 2400 | 2766 | 80166 |
| KERN COUNTY WA | M&I ENT=WT010 | 10A | 25 | 25 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 50 | 25 | 25 | 500 |
| KERN COUNTY WA | AGR ENT=WT001 | 10A | 3950 | 6750 | 11400 | 18500 | 42500 | 58500 | 65700 | 56100 | 24700 | 16100 | 5416 | 2994 | 312610 |
| KERN COUNTY WA | M&I ENT=WT010 | 11B | 167 | 167 | 167 | 167 | 167 | 167 | 167 | 166 | 166 | 166 | 166 | 167 | 2000 |
| KERN COUNTY WA | AGR ENT=WT001 | 11B | 2610 | 5220 | 10440 | 10440 | 13052 | 20881 | 31322 | 26102 | 5221 | 2610 | 1305 | 1305 | 130508 |
| KERN COUNTY WA | M GW ENT=WT008 | 12E | 500 | 1000 | 0 | 0 | 6250 | 24900 | 28400 | 21385 | 5225 | 7500 | 4500 | 1040 | 100700 |
| KERN COUNTY WA | AGR ENT=WT001 | 12E | 500 | 2000 | 0 | 2000 | 8000 | 28000 | 30700 | 24600 | 4446 | 3000 | 3700 | 0 | 106946 |
| KERN COUNTY WA | EXACOENT=WT115 | 12E | 15000 | 32000 | 50000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 97000 |
| KERN COUNTY WA | ANTEXACO=WT132 | 12E | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 83 | 87 | 1000 |
| KERN COUNTY WA | M GW ENT=WT008 | 13B | 0 | 0 | 0 | 0 | 1000 | 3000 | 4000 | 4000 | 0 | 0 | 0 | 0 | 12000 |
| KERN COUNTY WA | AGR ENT=WT001 | 13B | 0 | 0 | 2000 | 1000 | 5000 | 8800 | 9800 | 8000 | 300 | 200 | 5000 | 1700 | 41800 |
| KERN COUNTY WA | AGR ENT=WT001 | 14A | 500 | 1600 | 2700 | 2200 | 1500 | 2500 | 3000 | 4200 | 1000 | 800 | 200 | 100 | 20300 |
| KERN COUNTY WA | AGR ENT=WT001 | 14B | 1500 | 7500 | 7000 | 3700 | 5000 | 14100 | 16500 | 12500 | 4000 | 2000 | 1100 | 1000 | 75900 |
| KERN COUNTY WA | AGR ENT=WT001 | 14C | 700 | 3200 | 4000 | 2100 | 2600 | 6700 | 9600 | 8800 | 2500 | 1500 | 1000 | 300 | 43000 |
| KERN COUNTY WA | AGR ENT=WT001 | 15A | 1000 | 2000 | 4500 | 3600 | 5000 | 6000 | 7800 | 7200 | 3500 | 3000 | 1700 | 2200 | 47500 |
| KERN COUNTY WA | M&I ENT=WT010 | 16A | 0 | 0 | 368 | 960 | 648 | 544 | 744 | 744 | 192 | 200 | 0 | 0 | 4400 |
| KERN COUNTY WA | AGR ENT=WT001 | 16A | 200 | 200 | 1000 | 1080 | 1596 | 2036 | 2444 | 2744 | 1000 | 400 | 400 | 300 | 13400 |
| KERN COUNTY WA | EXCHMENT=WT099 | 19 | 0 | 0 | 0 | 200 | 300 | 300 | 300 | 300 | 300 | 300 | 0 | 0 | 2000 |
| KERN COUNTY WA | AGR ENT=WT001 | 31A | 3200 | 2600 | 3400 | 9400 | 12700 | 17000 | 17000 | 10600 | 7800 | 5200 | 2600 | 1500 | 93000 |
| *** TOTAL *** | | | 30535 | 64945 | 101908 | 62680 | 114446 | 207961 | 248010 | 201974 | 62883 | 44309 | 29595 | 15484 | 1184730 |
| COUNTY OF KINGS | AGR ENT=WT001 | 8C | 0 | 0 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 4000 |
| COUNTY OF KINGS | CYOV ENT=WT069 | 8C | 400 | 300 | 300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 |
| *** TOTAL *** | | | 400 | 300 | 700 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 5000 |
| OAK FLAT WD | AGR ENT=WT001 | 2A | 114 | 171 | 342 | 456 | 570 | 912 | 1026 | 1026 | 513 | 228 | 171 | 171 | 5700 |
| OAK FLAT WD | CYOV ENT=WT069 | 2A | 150 | 300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 450 |
| *** TOTAL *** | | | 264 | 471 | 342 | 456 | 570 | 912 | 1026 | 1026 | 513 | 228 | 171 | 171 | 6150 |
| TULARE LK BWSD | AGR ENT=WT001 | 8C | 0 | 0 | 1440 | 2680 | 1640 | 8440 | 9680 | 8880 | 2600 | 1040 | 3600 | 7400 | 47400 |
| TULARE LK BWSD | CYOV ENT=WT069 | 8C | 7200 | 6400 | 4000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17600 |
| TULARE LK BWSD | AGR ENT=WT001 | 8D | 0 | 0 | 2160 | 4020 | 2460 | 12660 | 14520 | 13320 | 3900 | 1560 | 5400 | 11100 | 71100 |
| TULARE LK BWSD | CYOV ENT=WT069 | 8D | 10800 | 9600 | 6000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 26400 |

FILE DUMP

FILE IDENTIFICATION: U199999 10/26/99. SHEET 3

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *** TOTAL *** | | | 18000 | 16000 | 13600 | 6700 | 4100 | 21100 | 24200 | 22200 | 6500 | 2600 | 9000 | 18500 | 162500 |
| AVEK WA | AGR ENT=WT001 | 19 | 2 | 101 | 201 | 315 | 420 | 450 | 490 | 300 | 190 | 160 | 30 | 5 | 2664 |
| AVEK WA | TRANSFER=WT067 | 19 | 100 | 80 | 85 | 110 | 120 | 170 | 235 | 175 | 160 | 120 | 60 | 85 | 1500 |
| AVEK WA | EXCHANGE=WT093 | 19 | 0 | 0 | 0 | 200 | 300 | 300 | 300 | 300 | 300 | 300 | 0 | 0 | 2000 |
| AVEK WA | M&I ENT=WT010 | 19C | 301 | 332 | 381 | 522 | 648 | 682 | 820 | 898 | 756 | 585 | 459 | 370 | 6754 |
| AVEK WA | AGR ENT=WT001 | 19C | 70 | 430 | 1781 | 1986 | 2511 | 3179 | 3773 | 3697 | 2761 | 955 | 260 | 40 | 21443 |
| AVEK WA | M&I ENT=WT010 | 20A | 1216 | 1472 | 2514 | 2795 | 3658 | 4629 | 4325 | 5002 | 3638 | 2723 | 2084 | 1378 | 35434 |
| AVEK WA | AGR ENT=WT001 | 20A | 8 | 8 | 8 | 10 | 10 | 10 | 11 | 11 | 10 | 8 | 8 | 8 | 110 |
| AVEK WA | ANTTRNBK=WT133 | 20A | 5457 | 5457 | 5457 | 5457 | 5457 | 5457 | 5457 | 5457 | 5457 | 5457 | 5457 | 5455 | 65482 |
| AVEK WA | M&I ENT=WT010 | 20B | 43 | 50 | 103 | 101 | 181 | 151 | 193 | 207 | 172 | 107 | 71 | 65 | 1444 |
| AVEK WA | M&I ENT=WT010 | 22A | 127 | 163 | 328 | 343 | 410 | 554 | 510 | 609 | 381 | 290 | 230 | 141 | 4086 |
| AVEK WA | AGR ENT=WT001 | 22A | 0 | 10 | 54 | 73 | 60 | 100 | 176 | 195 | 140 | 130 | 45 | 0 | 983 |
| *** TOTAL *** | | | 7324 | 8103 | 10912 | 11912 | 13775 | 15682 | 16290 | 16851 | 13965 | 10835 | 8704 | 7547 | 141900 |
| CASTAIC LAKE WA | M&I ENT=WT010 | 30 | 1000 | 1000 | 1250 | 1750 | 2500 | 3000 | 3500 | 3500 | 2250 | 3250 | 1000 | 1000 | 25000 |
| CASTAIC LAKE WA | ANTTRNBK=WT133 | 30 | 1375 | 1375 | 1375 | 1375 | 1375 | 1375 | 1375 | 1375 | 1375 | 1375 | 1375 | 1375 | 16500 |
| CASTAIC LAKE WA | AGR ENT=WT001 | 31A | 762 | 1143 | 1143 | 1143 | 1143 | 1143 | 1778 | 1905 | 508 | 0 | 1143 | 889 | 12700 |
| *** TOTAL *** | | | 3137 | 3518 | 3768 | 4268 | 5018 | 5518 | 6653 | 6780 | 4133 | 4625 | 3518 | 3264 | 54200 |
| COACHELLA VALLY | M&I ENT=WT010 | 26A | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| *** TOTAL *** | | | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| CRESTLINE-LA WA | M&I ENT=WT010 | 24 | 95 | 61 | 52 | 111 | 152 | 164 | 242 | 253 | 232 | 198 | 200 | 190 | 1950 |
| CRESTLINE-LA WA | ANTTRNBK=WT133 | 24 | 321 | 321 | 321 | 321 | 321 | 321 | 321 | 321 | 321 | 321 | 321 | 319 | 3850 |
| *** TOTAL *** | | | 416 | 382 | 373 | 432 | 473 | 485 | 563 | 574 | 553 | 519 | 521 | 509 | 5800 |
| DESERT WA | M GW ENT=WT008 | 26A | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| *** TOTAL *** | | | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| LITTLEROCK CR | M&I ENT=WT010 | 21 | 60 | 60 | 130 | 150 | 200 | 240 | 280 | 280 | 240 | 150 | 80 | 60 | 1930 |
| LITTLEROCK CR | AGR ENT=WT001 | 21 | 0 | 0 | 30 | 40 | 50 | 60 | 60 | 60 | 40 | 30 | 0 | 0 | 370 |
| *** TOTAL *** | | | 60 | 60 | 160 | 190 | 250 | 300 | 340 | 340 | 280 | 180 | 80 | 60 | 2300 |
| METROPOLITAN WD | STOR ENT=WT060 | 10A | 0 | 0 | 9000 | 9000 | 9000 | 9000 | 9000 | 9000 | 0 | 0 | 0 | 0 | 54000 |
| METROPOLITAN WD | STOR ENT=WT060 | 12E | 0 | 0 | 7000 | 10000 | 10000 | 12000 | 12000 | 12000 | 11000 | 10000 | 9000 | 7000 | 100000 |
| METROPOLITAN WD | M&I ENT=WT010 | 26A | 10609 | 0 | 14896 | 24080 | 35080 | 35080 | 24080 | 24080 | 24080 | 28080 | 22080 | 25080 | 267225 |
| METROPOLITAN WD | EXMCOENT=WT116 | 26A | 50000 | 50000 | 50000 | 50000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 200000 |
| METROPOLITAN WD | ANTEXMCO=WT131 | 26A | 16667 | 16667 | 16667 | 16667 | 16667 | 16667 | 16667 | 16667 | 16667 | 16667 | 16667 | 16663 | 200000 |
| METROPOLITAN WD | M&I ENT=WT010 | 28H | 3069 | 700 | 4000 | 5000 | 7000 | 9000 | 9000 | 10000 | 9000 | 8000 | 5000 | 4000 | 73769 |
| METROPOLITAN WD | BYPS ENT=WT059 | 28H | 22 | 0 | 14000 | 24000 | 24000 | 25000 | 25000 | 26000 | 25000 | 25000 | 23000 | 22000 | 233022 |
| METROPOLITAN WD | M&I ENT=WT010 | 28J | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 3600 |
| METROPOLITAN WD | M&I ENT=WT010 | 30 | 22080 | 16846 | 19846 | 21846 | 13846 | 14846 | 15846 | 33846 | 20846 | 25846 | 20846 | 21844 | 248384 |
| *** TOTAL *** | | | 102747 | 84513 | 135709 | 160893 | 115893 | 121893 | 111893 | 131893 | 106893 | 113893 | 96893 | 96887 | 1380000 |
| MOJAVE WA | TRANMENT=WT083 | 19 | 100 | 80 | 85 | 110 | 120 | 170 | 235 | 175 | 160 | 120 | 60 | 85 | 1500 |
| MOJAVE WA | M GW ENT=WT008 | 26A | 1530 | 1685 | 1845 | 2270 | 1870 | 3265 | 3265 | 3065 | 3265 | 3265 | 3265 | 3265 | 31800 |
| PALMDALE WD | M&I ENT=WT010 | 20A | 12 | 8 | 16 | 23 | 1584 | 1948 | 1958 | 1950 | 1950 | 1925 | 463 | 463 | 12300 |
| PALMDALE WD | EXMCOENT=WT116 | 20A | 1500 | 1500 | 1000 | 1000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5000 |
| PALMDALE WD | ANTEXMCO=WT131 | 20A | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 417 | 413 | 5000 |

FILE ID: V200000 DATE: 02/08/00
PAGE: 1

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COUNTY OF BUTTE TOTAL = 2890
TOT ENT = 800 M&I ENT = 800
TOT MISC = 2090 ANTTRNBK = 2090

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PLUMAS CO FCWCD TOTAL = 1510
TOT ENT = 1510 M&I ENT = 1510

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YUBA CITY TOTAL = 9600
TOT ENT = 1500 M&I ENT = 1500
TOT MISC = 8100 ANTTRNBK = 8100

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NAPA CO FCWCD TOTAL = 19825
TOT ENT = 19825 M&I ENT = 15325 ANTEXMCO = 1000 CYOVMENT = 3500

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SOLANO CO WA TOTAL = 58120
TOT ENT = 46720 M&I ENT = 13600 BEN ENT = 14670 VAL ENT = 2900 EXMCOENT = 7100 ANTEXMCO = 8450
TOT MISC = 11400 VAL PMT = 11400

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ZONE-7 ALAMEDA TOTAL = 77440
TOT ENT = 68000 M&I ENT = 22352 M GW ENT = 9367 TRANAENT = 12000 AGR ENT = 5976 STOR ENT = 13000
ANTEXMCO = 5305
TOT MISC = 9440 GEN WLNG = 1000 LOCAL = 8440

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ALAMEDA CO WD TOTAL = 44000
TOT ENT = 42000 M&I ENT = 29643 M GW ENT = 4857 STOR ENT = 7500
TOT MISC = 2000 LOCAL = 2000

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SANTA CLARA VWD TOTAL = 122000
TOT ENT = 122000 M&I ENT = 33000 M GW ENT = 11000 STOR ENT = 20000 EXMCOENT = 22000 ANTEXMCO = 36000

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SAN LUIS OBISPO TOTAL = 25000
TOT ENT = 4068 M&I ENT = 4068
TOT MISC = 20932 ANTTRNBK = 20932

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SANTA BARBARA TOTAL = 45486
TOT ENT = 32876 M&I ENT = 32876
TOT MISC = 12610 ANTTRNBK = 12610

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DUDLEY RIDGE WD TOTAL = 56370
TOT ENT = 56370 AGR ENT = 48370 EXACOENT = 3000 ANTEXACO = 5000

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EMPIRE WS ID TOTAL = 6000
TOT ENT = 3000 AGR ENT = 3000
TOT SUR = 3000 AGR SUR = 3000

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KERN COUNTY WA TOTAL = 1075580
TOT ENT = 1075580 M&I ENT = 6729 M GW ENT = 111849 AGR ENT = 901152 EXACOENT = 54850 ANTEXACO = 1000

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--------------------------------
COUNTY OF KINGS TOTAL =     4000
            TOT  ENT =     4000  AGR  ENT =     4000
--------------------------------
OAK FLAT WD     TOTAL =     6300
            TOT  ENT =     6300  AGR  ENT =     5700  CYOV ENT =      600
--------------------------------
TULARE LK BWSD  TOTAL =   148500
            TOT  ENT =   148500  AGR  ENT =   118500  CYOV ENT =    30000
--------------------------------
AVEK WA         TOTAL =   142251
            TOT  ENT =    68770  M&I  ENT =    38816  AGR  ENT =    29954
            TOT MISC =    73481  TRANSFER =     3851  ANTTRNBK =    69630
--------------------------------
CASTAIC LAKE WA TOTAL =    95200
            TOT  ENT =    36000  M&I  ENT =    28000  AGR  ENT =     8000
            TOT MISC =    59200  ANTTRNBK =    59200
--------------------------------
COACHELLA VALLY TOTAL =    23100
            TOT  ENT =    23100  M&I  ENT =    23100
--------------------------------
CRESTLINE-LA WA TOTAL =     5800
            TOT  ENT =     1950  M&I  ENT =     1950
            TOT MISC =     3850  ANTTRNBK =     3850
--------------------------------
DESERT WA       TOTAL =    38100
            TOT  ENT =    38100  M GW ENT =    38100
--------------------------------
LITTLEROCK CR   TOTAL =     2300
            TOT  ENT =     2300  M&I  ENT =     2070  AGR  ENT =      230
--------------------------------
METROPOLITAN WD TOTAL = 1507135
            TOT  ENT = 1507135  M&I  ENT = 1011636  BYPS ENT =   245499  STOR ENT =    50000  ANTEXMCO =   200000
--------------------------------
MOJAVE WA       TOTAL =    75800
            TOT  ENT =    13200  TRANMENT =     1500  M GW ENT =    11700
            TOT MISC =    62600  ANTTRNBK =    62600
--------------------------------
PALMDALE WD     TOTAL =    26624
            TOT  ENT =    26624  TRANMENT =      351  M&I  ENT =    20949  EXMCOENT =     3968  14B  M&I =     1356
--------------------------------
SAN BERNARDINO  TOTAL =   102600
            TOT  ENT =    20000  M&I  ENT =     7719  M GW ENT =    12281
            TOT MISC =    82600  ANTTRNBK =    82600
--------------------------------
SAN GABRIEL     TOTAL =    28800
            TOT  ENT =    14000  M GW ENT =    14000
            TOT MISC =    14800  ANTTRNBK =    14800
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SAN GORGONIO    TOTAL =     3000
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| AGENCY | WATER TYPE | RCH | OCT | NOV | DEC | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| COUNTY OF BUTTE | M&I ENT=WT010 | FR | 85 | 45 | 135 | 240 | 65 | 60 | 25 | 25 | 20 | 20 | 35 | 45 | 800 |
| COUNTY OF BUTTE | ANTTRNBK=WT133 | FR | 174 | 174 | 174 | 175 | 174 | 174 | 174 | 174 | 174 | 175 | 174 | 174 | 2050 |
| *** TOTAL *** | | | 259 | 219 | 3 9 | 415 | 239 | 234 | 199 | 199 | 194 | 195 | 209 | 219 | 2890 |
| PLUMAS CO FCWCD | M&I ENT=WT010 | FR | 90 | 90 | 95 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 95 | 90 | 1510 |
| *** TOTAL *** | | | 90 | 90 | 95 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 95 | 90 | 1510 |
| YUBA CITY | M&I ENT=WT010 | FR | 0 | 0 | 0 | 0 | 0 | 188 | 562 | 563 | 187 | 0 | 0 | 0 | 1500 |
| YUBA CITY | ANTTRNBK=WT133 | FR | 675 | 675 | 675 | 675 | 675 | 675 | 675 | 675 | 675 | 675 | 675 | 675 | 8100 |
| *** TOTAL *** | | | 675 | 675 | 675 | 675 | 675 | 863 | 1237 | 1238 | 862 | 675 | 675 | 675 | 9600 |
| NAPA CO FCWCD | CYOVMENT=WT077 | 3NB | 1000 | 1000 | 1500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3500 |
| NAPA CO FCWCD | M&I ENT=WT010 | 3NB | 882 | 920 | 1160 | 1197 | 1436 | 1568 | 1544 | 1685 | 1544 | 1389 | 1052 | 948 | 15325 |
| NAPA CO FCWCD | ANTEXMCO=WT131 | 3NB | 83 | 84 | 83 | 83 | 84 | 83 | 83 | 84 | 83 | 83 | 84 | 83 | 1000 |
| *** TOTAL *** | | | 1965 | 2004 | 2743 | 1280 | 1520 | 1651 | 1627 | 1769 | 1627 | 1472 | 1136 | 1031 | 19825 |
| SOLANO CO WA | M&I ENT=WT010 | 1NB | 450 | 450 | 475 | 1070 | 1420 | 1420 | 1420 | 1420 | 1420 | 1420 | 1370 | 1265 | 13600 |
| SOLANO CO WA | VAL PMT =WT071 | 1NB | 0 | 0 | 0 | 0 | 0 | 25 | 25 | 25 | 25 | 0 | 0 | 0 | 100 |
| SOLANO CO WA | EXMCONT=WT116 | 1NB | 1775 | 1775 | 1775 | 1775 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7100 |
| SOLANO CO WA | ANTEXMCO=WT131 | 1NB | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 625 | 7500 |
| SOLANO CO WA | BEN ENT =WT046 | 3NA | 955 | 955 | 970 | 1225 | 1380 | 1460 | 1460 | 1460 | 1315 | 1200 | 1300 | 990 | 14670 |
| SOLANO CO WA | VAL ENT =WT047 | 3NA | 0 | 0 | 0 | 0 | 0 | 500 | 500 | 500 | 500 | 500 | 400 | 0 | 2900 |
| SOLANO CO WA | VAL PMT =WT071 | 3NA | 900 | 900 | 900 | 900 | 1000 | 1000 | 1000 | 1000 | 1000 | 900 | 900 | 900 | 11300 |
| SOLANO CO WA | ANTEXMCO=WT131 | 3NA | 79 | 80 | 78 | 79 | 80 | 79 | 79 | 80 | 78 | 79 | 80 | 79 | 950 |
| *** TOTAL *** | | | 4784 | 4785 | 4823 | 5674 | 4505 | 5109 | 5109 | 5110 | 4963 | 4724 | 4675 | 3859 | 58120 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 1SB | 9 | 9 | 9 | 20 | 31 | 37 | 47 | 50 | 46 | 38 | 24 | 19 | 339 |
| ZONE-7 ALAMEDA | ANTEXMCO=WT131 | 1SB | 443 | 440 | 443 | 443 | 441 | 442 | 443 | 441 | 443 | 443 | 440 | 443 | 5305 |
| ZONE-7 ALAMEDA | GEN WLNG=WT079 | 2SB | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 0 | 0 | 0 | 1000 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 2SB | 0 | 0 | 56 | 854 | 985 | 1092 | 1352 | 167 | 106 | 1223 | 890 | 664 | 7389 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 2SB | 418 | 356 | 438 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1212 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 4SB | 676 | 502 | 686 | 905 | 945 | 913 | 671 | 684 | 945 | 695 | 670 | 695 | 8987 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 4SB | 32 | 124 | 190 | 329 | 545 | 577 | 582 | 565 | 325 | 282 | 132 | 32 | 3715 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 4SB | 12 | 132 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 144 |
| ZONE-7 ALAMEDA | M GW ENT=WT008 | 5SB | 0 | 0 | 0 | 0 | 0 | 97 | 0 | 0 | 146 | 137 | 0 | 0 | 380 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 5SB | 10 | 10 | 20 | 60 | 69 | 80 | 80 | 79 | 40 | 30 | 10 | 10 | 498 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 5SB | 160 | 160 | 160 | 160 | 160 | 53 | 0 | 0 | 0 | 9 | 160 | 160 | 1182 |
| ZONE-7 ALAMEDA | M&I ENT=WT010 | 6SB | 0 | 0 | 0 | 1049 | 1899 | 987 | 1507 | 2769 | 2247 | 2439 | 1691 | 36 | 14624 |
| ZONE-7 ALAMEDA | AGR ENT=WT001 | 6SB | 10 | 63 | 82 | 179 | 242 | 266 | 291 | 247 | 184 | 126 | 63 | 10 | 1763 |
| ZONE-7 ALAMEDA | LOCAL =WT024 | 6SB | 837 | 709 | 969 | 498 | 53 | 889 | 916 | 9 | 0 | 0 | 53 | 969 | 5902 |
| ZONE-7 ALAMEDA | TRANAENT=WT074 | 10A | 0 | 0 | 0 | 2000 | 2000 | 2000 | 2000 | 2000 | 2000 | 0 | 0 | 0 | 12000 |
| ZONE-7 ALAMEDA | STOR ENT=WT060 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13000 | 0 | 0 | 0 | 0 | 13000 |
| *** TOTAL *** | | | 2607 | 2505 | 3053 | 6497 | 7370 | 7433 | 7869 | 20011 | 7482 | 5422 | 4133 | 3038 | 77440 |
| ALAMEDA CO WD | M GW ENT=WT008 | 7SB | 0 | 0 | 0 | 0 | 0 | 957 | 800 | 800 | 1800 | 500 | 0 | 0 | 4857 |
| ALAMEDA CO WD | LOCAL =WT024 | 7SB | 0 | 0 | 0 | 0 | 0 | 0 | 1000 | 1000 | 0 | 0 | 0 | 0 | 2000 |
| ALAMEDA CO WD | M&I ENT=WT010 | 8SB | 2613 | 2360 | 2613 | 2528 | 2613 | 2528 | 2613 | 2613 | 2528 | 2613 | 1562 | 2459 | 29643 |
| ALAMEDA CO WD | STOR ENT=WT060 | 10A | 0 | 0 | 0 | 0 | 0 | 0 | 3750 | 3750 | 0 | 0 | 0 | 0 | 7500 |
| *** TOTAL *** | | | 2613 | 2360 | 2613 | 2528 | 2613 | 3485 | 8163 | 8163 | 4328 | 3113 | 1562 | 2459 | 44000 |

FILE IDENTIFICATION: V200000

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SANTA CLARA VWD | M&I ENT=WT010 | 9SB | 0 | 0 | 0 | 0 | 0 | 2700 | 7700 | 7600 | 5900 | 3800 | 500 | 4800 | 33000 |
| SANTA CLARA VWD | M GW ENT=WT008 | 9SB | 0 | 0 | 0 | 0 | 0 | 900 | 900 | 900 | 1800 | 2500 | 2000 | 2000 | 11000 |
| SANTA CLARA VWD | EXMCOENT=WT116 | 9SB | 0 | 1100 | 6000 | 4500 | 5400 | 5000 | 0 | 0 | 0 | 0 | 0 | 0 | 22000 |
| SANTA CLARA VWD | ANTEXMCO=WT131 | 9SB | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 36000 |
| SANTA CLARA VWD | STOR ENT=WT060 | 10A | 0 | 0 | 5000 | 5000 | 5000 | 5000 | 0 | 0 | 0 | 0 | 0 | 0 | 20000 |
| *** TOTAL *** | | | 3000 | 4100 | 14000 | 12500 | 13400 | 16600 | 11600 | 11500 | 10700 | 9300 | 5500 | 9800 | 122000 |
| SAN LUIS OBISPO | M&I ENT=WT010 | 33A | 276 | 256 | 285 | 310 | 349 | 392 | 423 | 428 | 381 | 385 | 301 | 282 | 4068 |
| SAN LUIS OBISPO | ANTTRNBK=WT133 | 33A | 1744 | 1745 | 1744 | 1744 | 1745 | 1744 | 1744 | 1745 | 1744 | 1744 | 1745 | 1744 | 20932 |
| *** TOTAL *** | | | 2020 | 2001 | 2029 | 2054 | 2094 | 2136 | 2167 | 2173 | 2125 | 2129 | 2046 | 2026 | 25000 |
| SANTA BARBARA | M&I ENT=WT010 | 33A | 1787 | 1599 | 2372 | 2818 | 3352 | 3416 | 3563 | 3507 | 3231 | 2886 | 2511 | 1834 | 32876 |
| SANTA BARBARA | ANTTRNBK=WT133 | 33A | 1051 | 1051 | 1050 | 1051 | 1051 | 1051 | 1051 | 1051 | 1050 | 1051 | 1051 | 1051 | 12610 |
| *** TOTAL *** | | | 2838 | 2650 | 3422 | 3869 | 4403 | 4467 | 4614 | 4558 | 4281 | 3937 | 3562 | 2885 | 45486 |
| DUDLEY RIDGE WD | AGR ENT=WT001 | 8D | 3700 | 1600 | 2900 | 3700 | 7200 | 8199 | 10762 | 9395 | 914 | 0 | 0 | 0 | 48370 |
| DUDLEY RIDGE WD | EXACOENT=WT115 | 8D | 3000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3000 |
| DUDLEY RIDGE WD | ANTEXACO=WT132 | 8D | 417 | 416 | 417 | 417 | 416 | 417 | 417 | 416 | 417 | 417 | 416 | 417 | 5000 |
| *** TOTAL *** | | | 7117 | 2016 | 3317 | 4117 | 7616 | 8616 | 11179 | 9811 | 1331 | 417 | 416 | 417 | 56370 |
| EMPIRE WS ID | AGR ENT=WT001 | 8C | 60 | 90 | 180 | 240 | 300 | 480 | 540 | 540 | 270 | 120 | 90 | 90 | 3000 |
| EMPIRE WS ID | AGR SUR=WT004 | 8C | 400 | 400 | 400 | 0 | 100 | 500 | 500 | 500 | 200 | 0 | 0 | 0 | 3000 |
| *** TOTAL *** | | | 460 | 490 | 580 | 240 | 400 | 980 | 1040 | 1040 | 470 | 120 | 90 | 90 | 6000 |
| KERN COUNTY WA | AGR ENT=WT001 | 9 | 585 | 585 | 4681 | 7021 | 8776 | 14042 | 19893 | 14042 | 2340 | 1170 | 2341 | 2697 | 78173 |
| KERN COUNTY WA | EXACOENT=WT115 | 9 | 2000 | 2900 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4900 |
| KERN COUNTY WA | M&I ENT=WT010 | 10A | 24 | 25 | 49 | 48 | 49 | 49 | 49 | 49 | 48 | 49 | 25 | 24 | 488 |
| KERN COUNTY WA | AGR ENT=WT001 | 10A | 3852 | 6582 | 11117 | 18040 | 41443 | 57045 | 64067 | 54705 | 17519 | 5949 | 4631 | 2920 | 287870 |
| KERN COUNTY WA | EXACOENT=WT115 | 10A | 5000 | 7000 | 8500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20500 |
| KERN COUNTY WA | M&I ENT=WT010 | 11B | 163 | 163 | 162 | 163 | 163 | 163 | 163 | 162 | 161 | 162 | 162 | 163 | 1950 |
| KERN COUNTY WA | AGR ENT=WT001 | 11B | 2545 | 5090 | 10181 | 10180 | 12728 | 20361 | 30544 | 25453 | 5091 | 2545 | 1272 | 1273 | 127263 |
| KERN COUNTY WA | EXACOENT=WT115 | 11B | 2500 | 2500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5000 |
| KERN COUNTY WA | M GW ENT=WT008 | 12E | 488 | 975 | 0 | 0 | 6094 | 24281 | 27694 | 20854 | 5095 | 7313 | 6339 | 1014 | 100147 |
| KERN COUNTY WA | AGR ENT=WT001 | 12E | 488 | 1950 | 0 | 1950 | 7801 | 27304 | 29937 | 23988 | 4336 | 2925 | 1658 | 0 | 102337 |
| KERN COUNTY WA | ANTEXACO=WT132 | 12E | 83 | 84 | 83 | 83 | 84 | 83 | 83 | 84 | 83 | 83 | 84 | 83 | 1000 |
| KERN COUNTY WA | M GW ENT=WT008 | 13B | 0 | 0 | 0 | 0 | 975 | 2926 | 3900 | 3901 | 0 | 0 | 0 | 0 | 11702 |
| KERN COUNTY WA | AGR ENT=WT001 | 13B | 0 | 0 | 975 | 0 | 2438 | 9264 | 11019 | 8581 | 488 | 0 | 4876 | 3120 | 40761 |
| KERN COUNTY WA | EXACOENT=WT115 | 13B | 3000 | 5750 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8750 |
| KERN COUNTY WA | AGR ENT=WT001 | 14A | 585 | 975 | 1950 | 1951 | 2535 | 3413 | 4388 | 3413 | 1658 | 780 | 390 | 585 | 22623 |
| KERN COUNTY WA | EXACOENT=WT115 | 14A | 600 | 1000 | 295 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1895 |
| KERN COUNTY WA | AGR ENT=WT001 | 14B | 1950 | 3901 | 4095 | 3901 | 6436 | 10434 | 10921 | 9946 | 5559 | 3120 | 975 | 1658 | 62896 |
| KERN COUNTY WA | EXACOENT=WT115 | 14B | 2000 | 4000 | 620 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6620 |
| KERN COUNTY WA | AGR ENT=WT001 | 14C | 1268 | 1462 | 2146 | 2437 | 4876 | 4973 | 4096 | 3218 | 2633 | 1267 | 1268 | 975 | 30619 |
| KERN COUNTY WA | EXACOENT=WT115 | 14C | 1300 | 1500 | 325 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3125 |
| KERN COUNTY WA | AGR ENT=WT001 | 15A | 488 | 487 | 3316 | 2925 | 6534 | 7508 | 7509 | 4875 | 2633 | 2146 | 975 | 975 | 40371 |
| KERN COUNTY WA | EXACOENT=WT115 | 15A | 500 | 500 | 505 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1505 |
| KERN COUNTY WA | M&I ENT=WT010 | 16A | 0 | 0 | 0 | 468 | 484 | 679 | 725 | 726 | 655 | 554 | 0 | 0 | 4291 |
| KERN COUNTY WA | AGR ENT=WT001 | 16A | 195 | 195 | 975 | 1560 | 2243 | 3218 | 3316 | 3120 | 1658 | 1463 | 195 | 195 | 18333 |
| KERN COUNTY WA | EXACOENT=WT115 | 16A | 200 | 200 | 155 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 555 |
| KERN COUNTY WA | AGR ENT=WT001 | 31A | 4291 | 3412 | 3413 | 6144 | 12189 | 16089 | 16090 | 11213 | 7314 | 5851 | 2437 | 1463 | 89906 |
| KERN COUNTY WA | EXACOENT=WT115 | 31A | 2000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2000 |

FILE DUMP

FILE IDENTIFICATION: V200000 02/08/00. SHEET 3

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *** TOTAL *** | | | 36105 | 51236 | 53543 | 56871 | 115848 | 201832 | 234394 | 188330 | 57271 | 35377 | 27628 | 17145 | 1075580 |
| COUNTY OF KINGS | AGR ENT=WT001 | 8C | 0 | 0 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 4000 |
| *** TOTAL *** | | | 0 | 0 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 400 | 4000 |
| OAK FLAT WD | AGR ENT=WT001 | 2A | 114 | 171 | 342 | 456 | 570 | 912 | 1026 | 1026 | 513 | 228 | 171 | 171 | 5700 |
| OAK FLAT WD | CYOV ENT=WT069 | 2A | 200 | 400 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 600 |
| *** TOTAL *** | | | 314 | 571 | 342 | 456 | 570 | 912 | 1026 | 1026 | 513 | 228 | 171 | 171 | 6300 |
| TULARE LK BWSD | AGR ENT=WT001 | 8C | 0 | 0 | 1600 | 2040 | 2000 | 9520 | 9880 | 10080 | 800 | 400 | 3760 | 7320 | 47400 |
| TULARE LK BWSD | CYOV ENT=WT069 | 8C | 8000 | 4000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12000 |
| TULARE LK BWSD | AGR ENT=WT001 | 8D | 0 | 0 | 2400 | 3060 | 3000 | 14280 | 14820 | 15120 | 1200 | 600 | 5640 | 10980 | 71100 |
| TULARE LK BWSD | CYOV ENT=WT069 | 8D | 12000 | 6000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18000 |
| *** TOTAL *** | | | 20000 | 10000 | 4000 | 5100 | 5000 | 23800 | 24700 | 25200 | 2000 | 1000 | 9400 | 18300 | 148500 |
| AVEK WA | AGR ENT=WT001 | 19 | 2 | 2 | 110 | 225 | 350 | 570 | 595 | 595 | 390 | 270 | 30 | 10 | 3149 |
| AVEK WA | TRANSFER=WT067 | 19 | 100 | 80 | 85 | 110 | 120 | 170 | 235 | 175 | 160 | 120 | 60 | 85 | 1500 |
| AVEK WA | ANTTRNBK=WT133 | 19 | 5802 | 5803 | 5802 | 5803 | 5802 | 5803 | 5802 | 5803 | 5802 | 5803 | 5802 | 5803 | 69630 |
| AVEK WA | M&I ENT=WT010 | 19C | 364 | 379 | 421 | 542 | 681 | 791 | 911 | 981 | 812 | 624 | 494 | 406 | 7406 |
| AVEK WA | AGR ENT=WT001 | 19C | 230 | 580 | 1421 | 2682 | 3351 | 3386 | 4494 | 4546 | 3076 | 1300 | 345 | 195 | 25606 |
| AVEK WA | TRANSFER=WT067 | 19C | 0 | 0 | 0 | 200 | 300 | 300 | 300 | 300 | 300 | 200 | 100 | 0 | 2000 |
| AVEK WA | M&I ENT=WT010 | 20A | 1196 | 1036 | 1414 | 1625 | 2472 | 3081 | 3766 | 4344 | 2952 | 2536 | 1866 | 1525 | 27813 |
| AVEK WA | AGR ENT=WT001 | 20A | 15 | 15 | 17 | 21 | 21 | 21 | 21 | 21 | 21 | 16 | 15 | 16 | 220 |
| AVEK WA | TRANSFER=WT067 | 20A | 12 | 8 | 16 | 23 | 35 | 48 | 58 | 50 | 50 | 25 | 13 | 13 | 351 |
| AVEK WA | M&I ENT=WT010 | 22A | 144 | 118 | 172 | 215 | 342 | 402 | 518 | 617 | 351 | 297 | 246 | 175 | 3597 |
| AVEK WA | AGR ENT=WT001 | 22A | 2 | 24 | 109 | 82 | 119 | 138 | 165 | 165 | 105 | 55 | 12 | 3 | 979 |
| *** TOTAL *** | | | 7867 | 8045 | 9567 | 11528 | 13593 | 14710 | 16865 | 17597 | 14019 | 11246 | 8983 | 8231 | 142251 |
| CASTAIC LAKE WA | M&I ENT=WT010 | 30 | 1400 | 1260 | 1680 | 2240 | 2520 | 2800 | 3920 | 3920 | 2940 | 2520 | 1400 | 1400 | 28000 |
| CASTAIC LAKE WA | ANTTRNBK=WT133 | 30 | 4541 | 4543 | 4541 | 4541 | 4543 | 4541 | 4541 | 4543 | 4541 | 4541 | 4543 | 4541 | 54500 |
| CASTAIC LAKE WA | AGR ENT=WT001 | 31A | 500 | 500 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 0 | 0 | 0 | 8000 |
| CASTAIC LAKE WA | ANTTRNBK=WT133 | 31A | 392 | 391 | 392 | 392 | 391 | 392 | 392 | 391 | 392 | 392 | 391 | 392 | 4700 |
| *** TOTAL *** | | | 6833 | 6694 | 7613 | 8173 | 8454 | 8733 | 9853 | 9854 | 8873 | 7453 | 6334 | 6333 | 95200 |
| COACHELLA VALLY | M&I ENT=WT010 | 26A | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| *** TOTAL *** | | | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 1925 | 23100 |
| CRESTLINE-LA WA | M&I ENT=WT010 | 24 | 95 | 61 | 52 | 111 | 152 | 164 | 242 | 253 | 232 | 198 | 200 | 190 | 1950 |
| CRESTLINE-LA WA | ANTTRNBK=WT133 | 24 | 321 | 321 | 320 | 321 | 321 | 321 | 321 | 321 | 320 | 321 | 321 | 321 | 3850 |
| *** TOTAL *** | | | 416 | 382 | 372 | 432 | 473 | 485 | 563 | 574 | 552 | 519 | 521 | 511 | 5800 |
| DESERT WA | M GW ENT=WT008 | 26A | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| *** TOTAL *** | | | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 3175 | 38100 |
| LITTLEROCK CR | M&I ENT=WT010 | 21 | 90 | 90 | 150 | 160 | 220 | 230 | 240 | 240 | 210 | 170 | 150 | 120 | 2070 |
| LITTLEROCK CR | AGR ENT=WT001 | 21 | 0 | 0 | 0 | 0 | 30 | 40 | 60 | 60 | 40 | 0 | 0 | 0 | 230 |
| *** TOTAL *** | | | 90 | 90 | 150 | 160 | 250 | 270 | 300 | 300 | 250 | 170 | 150 | 120 | 2300 |

FILE IDENTIFICATION: V200000 FILE DUMP 02/08/00. SHEET 4

| AGENCY | WATER TYPE | RCH | JAN | FEB | MAR | APR | MAY | JUN | JLY | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| METROPOLITAN WD | ANTEXMCO=WT131 | 3 | 16667 | 16666 | 16667 | 16667 | 16666 | 16667 | 16667 | 16666 | 16667 | 16667 | 16666 | 16667 | 200000 |
| METROPOLITAN WD | STOR ENT=WT060 | 12E | 0 | 0 | 8330 | 8330 | 8330 | 8330 | 8330 | 8350 | 0 | 0 | 0 | 0 | 50000 |
| METROPOLITAN WD | M&I ENT=WT010 | 26A | 20931 | 13758 | 14433 | 29502 | 16889 | 22296 | 24096 | 24903 | 21509 | 32151 | 25320 | 13582 | 259370 |
| METROPOLITAN WD | M&I ENT=WT010 | 28H | 4030 | 3481 | 4500 | 6200 | 7267 | 8500 | 9289 | 10582 | 8500 | 7770 | 5799 | 5158 | 81076 |
| METROPOLITAN WD | BYPS ENT=WT059 | 28H | 9037 | 10125 | 17610 | 20424 | 24589 | 23796 | 24589 | 18559 | 23796 | 24589 | 23796 | 24589 | 245499 |
| METROPOLITAN WD | M&I ENT=WT010 | 28J | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 300 | 3600 |
| METROPOLITAN WD | M&I ENT=WT010 | 30 | 55273 | 50312 | 60462 | 63724 | 45805 | 46504 | 48656 | 50320 | 47448 | 68676 | 66469 | 63941 | 667590 |
| *** TOTAL *** | | | 106238 | 94642 | 122302 | 145147 | 119846 | 126393 | 131927 | 129680 | 118220 | 150153 | 138350 | 124237 | 1507135 |
| MOJAVE WA | TRANMENT=WT083 | 19 | 100 | 80 | 85 | 110 | 120 | 170 | 235 | 175 | 160 | 120 | 60 | 85 | 1500 |
| MOJAVE WA | ANTTRNBK=WT133 | 19 | 5217 | 5216 | 5217 | 5217 | 5216 | 5217 | 5217 | 5216 | 5217 | 5217 | 5216 | 5217 | 62600 |
| MOJAVE WA | M GW ENT=WT008 | 22B | 1400 | 1200 | 1200 | 300 | 210 | 260 | 260 | 260 | 335 | 2125 | 2150 | 2000 | 11700 |
| *** TOTAL *** | | | 6717 | 6496 | 6502 | 5627 | 5546 | 5647 | 5712 | 5651 | 5712 | 7462 | 7426 | 7302 | 75800 |
| PALMDALE WD | TRANMENT=WT083 | 20A | 12 | 8 | 16 | 23 | 35 | 48 | 58 | 50 | 50 | 25 | 13 | 13 | 351 |
| PALMDALE WD | 14B M&I=WT043 | 20A | 339 | 339 | 339 | 339 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1356 |
| PALMDALE WD | M&I ENT=WT010 | 20B | 694 | 800 | 1500 | 1500 | 1845 | 2250 | 2285 | 2300 | 2300 | 1845 | 1785 | 1845 | 20949 |
| PALMDALE WD | EXMCOENT=WT116 | 20B | 800 | 900 | 1100 | 1168 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3968 |
| *** TOTAL *** | | | 1845 | 2047 | 2955 | 3030 | 1880 | 2298 | 2343 | 2350 | 2350 | 1870 | 1798 | 1858 | 26624 |
| SAN BERNARDINO | M&I ENT=WT010 | 26A | 390 | 585 | 584 | 780 | 780 | 779 | 839 | 838 | 780 | 584 | 390 | 390 | 7719 |
| SAN BERNARDINO | M GW ENT=WT008 | 26A | 390 | 585 | 779 | 1365 | 1365 | 1364 | 1365 | 1364 | 1365 | 974 | 780 | 585 | 12281 |
| SAN BERNARDINO | ANTTRNBK=WT133 | 26A | 6883 | 6884 | 6883 | 6883 | 6884 | 6883 | 6883 | 6884 | 6883 | 6883 | 6884 | 6883 | 82600 |
| *** TOTAL *** | | | 7663 | 8054 | 8246 | 9028 | 9029 | 9026 | 9087 | 9086 | 9028 | 8441 | 8054 | 7858 | 102600 |
| SAN GABRIEL | M GW ENT=WT008 | 26A | 0 | 0 | 0 | 0 | 1000 | 3000 | 3100 | 3100 | 3000 | 800 | 0 | 0 | 14000 |
| SAN GABRIEL | ANTTRNBK=WT133 | 26A | 1233 | 1234 | 1233 | 1233 | 1234 | 1233 | 1233 | 1234 | 1233 | 1233 | 1234 | 1233 | 14800 |
| *** TOTAL *** | | | 1233 | 1234 | 1233 | 1233 | 2234 | 4233 | 4333 | 4334 | 4233 | 2033 | 1234 | 1233 | 28800 |
| SAN GORGONIO | ANTTRNBK=WT133 | 26A | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 3000 |
| *** TOTAL *** | | | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 3000 |
| VENTURA CO FCD | M GW ENT=WT008 | 29H | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3150 | 0 | 0 | 0 | 3150 |
| VENTURA CO FCD | M&I ENT=WT010 | 30 | 1154 | 1154 | 1154 | 1154 | 1154 | 1154 | 1154 | 1154 | 1154 | 1154 | 2654 | 2656 | 16850 |
| *** TOTAL *** | | | 1154 | 1154 | 1154 | 1154 | 1154 | 1154 | 1154 | 1154 | 4304 | 1154 | 2654 | 2656 | 20000 |
| SHELL CAL PROD. | REPAYMNT=WT009 | 11B | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *** TOTAL *** | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| FISH & GAME | REC/F&WL=WT002 | 3 | 20 | 20 | 20 | 50 | 50 | 150 | 200 | 200 | 200 | 50 | 20 | 20 | 1000 |
| FISH & GAME | REC/F&WL=WT002 | 5 | 0 | 0 | 10 | 30 | 40 | 40 | 40 | 30 | 10 | 0 | 0 | 0 | 200 |
| *** TOTAL *** | | | 20 | 20 | 30 | 80 | 90 | 190 | 240 | 230 | 210 | 50 | 20 | 20 | 1200 |
| PARKS & RECREAT | REC/F&WL=WT002 | 3 | 3 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 9 | 9 | 4 | 3 | 70 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 5SB | 34 | 80 | 34 | 33 | 34 | 83 | 34 | 34 | 33 | 34 | 33 | 34 | 400 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 1 | 4 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 50 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 20A | 10 | 10 | 20 | 20 | 20 | 26 | 24 | 20 | 20 | 10 | 10 | 10 | 200 |
| REC/FISH&WILDLF | REC/F&WL=WT002 | 24 | 9 | 9 | 18 | 18 | 18 | 22 | 20 | 18 | 18 | 9 | 9 | 9 | 180 |

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# Bay-Delta Region

Resources Agency
Dept of Fish and Game

search

My CA CVBDB

## Midwater Trawl

**Reporting Date: January 9, 2008**

**YOUNG-OF-THE-YEAR STRIPED BASS INDICES**

| Survey | 2005 | 2006 | 2007 |
|---|---|---|---|
| September | 40 | 236 | 32 |
| October | 29 | 18 | 34 |
| November | 26 | 39 | 14 |
| December | 26 | 70 | 2 |
| Fall Index | 121 | 363 | 82 |

**DELTA SMELT INDICES**

| Survey | 2005 | 2006 | 2007 |
|---|---|---|---|
| September | 3 | 33 | 9 |
| October | 10 | 3 | 4 |
| November | 7 | 4 | 5 |
| December | 7 | 1 | 10 |
| Fall Index | 27 | 41 | 28 |

**The Fall Midwater Trawl Index is the sum of the four monthly indices.**

- **Table of monthly abundance indices of selected species from Fall Midwater Trawl Survey, 1967 - 2007.**
- **Trends in abundance of selected species from Fall Midwater Trawl Survey, 1967 - 2007.**

**Back to Top of Page**

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# The California Environmental Quality Act
# Mitigation for Global Warming Impacts

## California Attorney General's Office

Under the California Environmental Quality Act (CEQA), local agencies have a very important role to play in California's fight against global warming. Local agencies must require feasible mitigation for global warming impacts caused by the projects they permit, and must include feasible mitigation in their own projects. By the sum of their individual decisions, local agencies are helping to move the State away from "business as usual" and toward a low-carbon future.

This document provides general information that may be helpful to local agencies in carrying out their duty to mitigate global warming. The measures set forth in this package are examples; the list is not intended to be exhaustive. Moreover, the measures cited may not be appropriate for every project. The lead agency must use its own informed judgment in deciding which measures it will analyze, and which measures it will require, for a given project.

The first section of this document lists examples of mitigation measures that could be undertaken or funded by a diverse range of projects. Such projects may include, for example, a private residential or commercial development, a public works or infrastructure project, a local "Climate Action Plan," or a general plan update (where a given measure could be fashioned into a goal, policy, program, or land use designation), as appropriate. The lead agency must design mitigation measures to be enforceable, and commit sufficient resources to enforcement.

In general, a given mitigation measure should not be considered in isolation, but as part of a larger set of measures that, working together, reduce greenhouse gas emissions and the effects of global warming. And in selecting a mitigation set, the relevant environmental goal must kept in view – emissions reductions not just for the project, but for the region and for California.

The second section of this document lists examples of potential mitigation in the general plan context. This section is included both to suggest how the larger set of measures set forth in the first section could be incorporated into a general plan, as well as to identify measures that are general plan specific. The measures in the second section may also be appropriate for inclusion in larger scale plans, including regional plans (*e.g.*, blueprint plans) and specific plans.

The third section provides links to sources of information on global warming impacts and mitigation measures. The list is not complete, but may be a helpful start for local agencies seeking more information to carry out their CEQA obligations as they relate to global warming.

The Endnotes set forth just some of the many examples of exemplary mitigation measures already being implemented by local government and agencies, utilities, private industry, and others. As these examples evidence, California at every level is taking up the challenge, devising new and innovative solutions, and leading the charge in the fight against global warming.

## (1) Mitigation Measures

### Energy Efficiency[1]

- Design building to be energy efficient. Site buildings to take advantage of shade, prevailing winds, landscaping and sun screens to reduce energy use.[2]
- Install efficient lighting and lighting control systems. Use daylight as an integral part of lighting systems in commercial buildings.
- Install light colored "cool" roofs, cool pavements, and strategically placed shade trees.[3]
- Provide information on energy management services for large energy users.[4]
- Install energy efficient heating and cooling systems, appliances and equipment, and control systems.[5]
- Install light emitting diodes (LEDs) for traffic, street and other outdoor lighting.[6]
- Limit the hours of operation of outdoor lighting.
- Use solar heating, automatic covers, and efficient pumps and motors for pools and spas.[7]
- Provide education on energy efficiency.[8]

### Renewable Energy

- Install solar and wind power systems, solar and tankless hot water heaters, and energy-efficient heating ventilation and air conditioning. Educate consumers about existing incentives.[9]
- Install solar panels on carports and over parking areas where appropriate.[10]
- Use combined heat and power in appropriate applications.[11]

### Water Conservation and Efficiency[12]

- Create water-efficient landscapes.[13]
- Install water-efficient irrigation systems and devices, such as soil moisture-based irrigation controls.
- Use reclaimed water for landscape irrigation in new developments and on public property. Install the infrastructure to deliver and use reclaimed water.
- Design buildings to be water-efficient. Install water-efficient fixtures and appliances.
- Use graywater. (Graywater is untreated household waste water from bathtubs, showers, bathroom wash basins, and water from clothes washing machines.) For example, install dual plumbing in all new development allowing graywater to be used for landscape irrigation.[14]
- Restrict watering methods (*e.g.*, prohibit systems that apply water to non-vegetated surfaces) and control runoff.
- Restrict the use of water for cleaning outdoor surfaces and vehicles.
- Implement low-impact development practices that maintain the existing hydrologic character of the site to manage storm water and protect the environment. (Retaining storm water runoff onsite can drastically reduce the need for energy-intensive imported water at the site.)[15]
- Devise a comprehensive water conservation strategy appropriate for the project and location. The strategy may include many of the specific items listed above, plus other innovative measures

that are appropriate to the specific project.

- Provide education about water conservation and available programs and incentives.[16]

**Solid Waste Measures**

- Reuse and recycle construction and demolition waste (including, but not limited to, soil, vegetation, concrete, lumber, metal, and cardboard).
- Provide interior and exterior storage areas for recyclables and green waste and adequate recycling containers in public areas.
- Recover by-product methane to generate electricity.[17]
- Provide education and publicity about reducing waste and available recycling services.[18]

**Land Use Measures**

- Incorporate mixed-use, infill, and higher density development to reduce vehicle trips, promote alternatives to individual vehicle travel, and promote efficient delivery of services and goods. (Infill development generates fewer vehicle miles traveled per capita and reduced emissions of greenhouse gases, and denser development is associated with increased public transit use.)[19]
- Avoid development that will increase passenger vehicle miles traveled.
- Incorporate public transit into project design were appropriate.[20]
- Preserve and create open space and parks. Preserve existing trees, and plant replacement trees at a set ratio.
- Develop "brownfields" and other underused or defunct properties near existing public transportation and jobs.
- Include pedestrian and bicycle-only streets and plazas within developments. Create travel routes that ensure that destinations may be reached conveniently by public transportation, bicycling or walking.[21]

**Transportation and Motor Vehicles**

- Limit idling time for commercial vehicles, including delivery and off-road construction vehicles.
- Use low or zero-emission vehicles, including off-road construction vehicles.
- Promote ride sharing programs *e.g.*, by designating a certain percentage of parking spaces for ride sharing vehicles, designating adequate passenger loading and unloading and waiting areas for ride sharing vehicles, and providing a web site or message board for coordinating rides.
- Create car sharing programs. Accommodations for such programs include providing parking spaces for the car share vehicles at convenient locations accessible by public transportation.[22]
- Create local "light vehicle" networks, such as neighborhood electric vehicle (NEV) systems.[23]
- Provide the necessary facilities and infrastructure to encourage the use of low or zero-emission vehicles (*e.g.*, electric vehicle charging facilities and conveniently located alternative fueling stations).
- Increase the cost of driving and parking private vehicles by, *e.g.*, imposing tolls and parking fees.
- Build or fund a transportation center where various public transportation modes intersect.

- Encourage the use of public transit systems by enhancing safety and cleanliness on vehicles and in and around stations, and convenience by, *e.g.*, installing electronic signs that provide real-time information on schedules and service.
- Provide shuttle service to public transit.
- Provide public transit incentives such as free or low-cost monthly transit passes.
- Incorporate bicycle lanes and/or routes into street systems, new subdivisions, and large developments.
- Incorporate bicycle-friendly intersections into street design.
- For commercial projects, provide adequate bicycle parking near building entrances to promote cyclist safety, security, and convenience. For large employers, provide facilities that encourage bicycle commuting, including, *e.g.*, locked bicycle storage or covered or indoor bicycle parking.
- Create bicycle lanes and walking paths directed to the location of schools, parks and other destination points.[24]
- Restore and/or expand school bus services.
- Institute a formal telecommute work program. Provide information, training, and incentives to encourage participation. Provide incentives for equipment purchases to allow high-quality teleconferences.
- Provide information on all options for individuals and businesses to reduce transportation-related emissions. Provide education and information about public transportation.

**Carbon Offsets**

In some instances, a lead agency may decide to go beyond measures that will directly reduce a project's emissions. A lead agency may consider whether carbon offsets would be appropriate. The project proponent could, for example, fund off-site projects (*e.g.*, alternative energy projects, or energy or water audits for existing projects) that will reduce carbon emissions, conduct an audit of its other existing operations and agree to retrofit, or purchase "credits" from another entity that will undertake mitigation projects. The lead agency should ensure that any mitigation taking the form of carbon offsets is specifically identified and that such mitigation will in fact occur.

## (2) General Plans

Mitigation measures for global warming may be reflected in a general plan as goals, policies, or programs; in land use designations; and/or as additional mitigation measures identified during the CEQA review process. Many of the mitigation measures listed above may be appropriate for inclusion in a general plan. In addition, a non-exhaustive list of measures specific to the general plan context follows. The examples are listed under required general plan elements. A given example may, however, be appropriate for inclusion in more than one element, or in a different element than listed. Global warming mitigation measures may, alternatively, be included in an optional Climate Change or Energy element.

**Conservation[25]**

- Climate Action Plan or Policy: Include a comprehensive climate change action plan that requires a baseline inventory of greenhouse gas emissions from all sources by a date certain;

greenhouse gas emissions reduction targets and deadlines; and enforceable greenhouse gas emissions reduction measures.[26] (Note: If the Climate Action Plan complies with the requirements of Section 15064(h)(3) of the CEQA Guidelines, it may allow for the streamlining of individual projects that comply with the plan's requirements.)

- Climate Action Plan Implementation Program: Include mechanisms to ensure regular review of progress toward the emission reduction targets established by the Climate Action Plan, report progress to the public and responsible officials, and revise the plan as appropriate, using principles of adaptive management. Allocate funding to implement the plan. Fund staff to oversee implementation of the plan.
- Strengthen local building codes for new construction and renovation to require a higher level of energy efficiency.[27]
- Require that all new government buildings, and all major renovations and additions, meet identified green building standards.[28]
- Adopt a "Green Building Program" to require or encourage green building practices and materials.[29] The program could be implemented through, *e.g.*, a set of green building ordinances.
- Require orientation of buildings to maximize passive solar heating during cool seasons, avoid solar heat gain during hot periods, enhance natural ventilation, and promote effective use of daylight. Orientation should optimize opportunities for on-site solar generation.
- Provide permitting-related and other incentives for energy efficient building projects, *e.g.*, by giving green projects priority in plan review, processing and field inspection services.[30]
- Conduct energy efficiency audits of existing buildings by checking, repairing, and readjusting heating, ventilation, air conditioning, lighting, water heating equipment, insulation and weatherization.[31] Offer financial incentives for adoption of identified efficiency measures.[32]
- Provide innovative, low-interest financing for energy efficiency and alternative energy projects. For example, allow property owners to pay for energy efficiency improvements and solar system installation through long-term assessments on individual property tax bills.[33]
- Fund incentives to encourage the use of energy efficient vehicles, equipment and lighting.[34] Provide financial incentives for adoption of identified efficiency measures.
- Require environmentally responsible government purchasing.[35] Require or give preference to products that reduce or eliminate indirect greenhouse gas emissions, *e.g.*, by giving preference to recycled products over those made from virgin materials.[36]
- Require that government contractors take action to minimize greenhouse gas emissions by, for example, using low or zero-emission vehicles and equipment.
- Adopt a "heat island" mitigation plan that requires cool roofs, cool pavements, and strategically placed shade trees.[37] (Darker colored roofs, pavement, and lack of trees may cause temperatures in urban environments to increase by as much as 6-8 degrees Fahrenheit as compared to surrounding areas.[38]) Adopt a program of building permit enforcement for re-roofing to ensure compliance with existing state building requirements for cool roofs on non-residential buildings.
- Adopt a comprehensive water conservation strategy. The strategy may include, but not be limited to, imposing restrictions on the time of watering, requiring water-efficient irrigation equipment, and requiring new construction to offset demand so that there is no net increase in water use.[39]
- Adopt water conservation pricing, *e.g.*, tiered rate structures, to encourage efficient water use.[40]
- Adopt water-efficient landscape ordinances.[41]

- Strengthen local building codes for new construction and implement a program to renovate existing buildings to require a higher level of water efficiency.
- Adopt energy and water efficiency retrofit ordinances that require upgrades as a condition of issuing permits for renovations or additions, and on the sale of residences and buildings.[42]
- Provide individualized water audits to identify conservation opportunities.[43] Provide financial incentives for adopting identified efficiency measures.
- Provide water audits for large landscape accounts. Provide financial incentives for efficient irrigation controls and other efficiency measures.
- Require water efficiency training and certification for irrigation designers and installers, and property managers.[44]
- Implement or expand city or county-wide recycling and composting programs for residents and businesses. Require commercial and industrial recycling.
- Extend the types of recycling services offered (*e.g.*, to include food and green waste recycling).
- Establish methane recovery in local landfills and wastewater treatment plants to generate electricity.[45]
- Implement Community Choice Aggregation (CCA) for renewable electricity generation, if feasible. (CCA allows cities and counties, or groups of them, to aggregate the electric loads of customers within their jurisdictions for purposes of procuring electrical services. CCA allows the community to choose what resources will serve their loads and can significantly increase renewable energy).[46]
- Preserve existing conservation areas (*e.g.*, forested areas, agricultural lands, wildlife habitat and corridors, wetlands, watersheds, and groundwater recharge areas) that provide carbon sequestration benefits.
- Establish a mitigation program for development of conservation areas. Impose mitigation fees on development of such lands and use funds generated to protect existing, or create replacement, conservation areas.
- Provide public education and information about options for reducing greenhouse gas emissions through responsible purchasing, conservation, and recycling.

**Land Use**[47]

- Adopt land use designations to carry out policies designed to reduce greenhouse gas emissions, *e.g.*, policies to reduce vehicle miles traveled, encourage development near existing public transportation corridors, encourage alternative modes of transportation, and promote infill, mixed use, and higher density development.
- Concentrate commercial, mixed use, and medium to higher density residential development in areas near jobs, transit routes, schools, shopping areas and recreation.
- Identify and facilitate the development of land uses not already present in local districts – such as supermarkets, parks, and schools in neighborhoods; or residential uses in business districts – to reduce vehicle miles traveled and encourage bicycling and walking.
- Increase density in single family residential areas located near transit routes or commercial areas. For example, allow duplexes in residential areas, and allow increased height multi-unit buildings on main arterial streets, under specified conditions.
- Impose minimum residential densities in areas designated for transit-oriented, mixed use

development to ensure higher density in these areas.

- Require bike lanes and bicycle/pedestrian paths.
- Site schools to increase the potential for students to walk and bike to school.
- Enact ordinances and programs to limit or prohibit "sprawl" – development that requires additional or longer passenger vehicle commutes between employment, services, and residential areas.[48]
- In areas designated for mixed use, require rather than merely allow mixed use.
- Promote infill, mixed use, and higher density development by, for example, reducing developer fees or granting property tax credits for qualifying projects;[49] providing fast-track permit processing; reducing processing fees; funding infrastructure loans; and giving preference for infrastructure improvements in these areas.
- Where appropriate, adopt and enforce growth boundaries to encourage infill. Provide new services and infrastructure only within the growth boundary.[50]
- Transfer a portion of the county's housing allocation to existing cities to encourage infill were services and employment already exist; preserve open space, agricultural land, and water quality; and reduce vehicle miles traveled.
- Require best management practices in agriculture and animal operations to reduce emissions, conserve energy and water, and utilize alternative energy sources, including biogas, wind and solar.

**Circulation[51]**

- In conjunction with measures that encourage public transit, ride sharing, bicycling and walking, implement circulation improvements that reduce vehicle idling. For example, coordinate controlled intersections so that traffic passes more efficiently through congested areas.[52]
- Create an interconnected transportation system that allows a shift in travel from private passenger vehicles to alternative modes, including public transit, ride sharing, bicycling and walking. Before funding transportation improvements that increase vehicle miles traveled, consider alternatives such as increasing public transit or improving bicycle or pedestrian travel routes.
- Give funding preference to investment in public transit over investment in infrastructure for private automobile traffic.[53]
- Include safe and convenient bicycle and pedestrian access in all transportation improvement projects. Ensure that non-motorized transportation systems are connected and not interrupted by impassable barriers, such as freeways[54] and include amenities such as secure bicycle parking.
- Provide adequate and affordable public transportation choices including expanded bus routes and service and other transit choices such as shuttles, light rail, and rail where feasible.
- Assess transportation impact fees on new development in order to maintain and increase public transit service.[55]
- Provide public transit incentives, including free or reduced fare areas.[56]
- Adopt a comprehensive parking policy that discourages private vehicle use and encourages the use of alternative transportation.[57] For example, reduce parking for private vehicles while increasing options for alternative transportation; eliminate minimum parking requirements for new buildings; "unbundle" parking (require that parking is paid for separately and is not

included in rent for residential or commercial space); and set appropriate pricing for on-street parking.

- Develop school transit plans to substantially reduce automobile trips to, and congestion surrounding, schools. (According to some estimates, parents driving their children to school account for 20-25% of the morning commute.) Plans may address, *e.g.*, necessary infrastructure improvements and potential funding sources; replacing older diesel buses with low or zero-emission vehicles; mitigation fees to expand school bus service; and Safe Routes to School programs[58] and other formal efforts to increase walking and biking by students.
- Create financing programs for the purchase or lease of vehicles used in employer ride sharing programs.
- Enter into partnerships to create and/or expand polluting vehicle buy-back programs to include vehicles with high greenhouse gas emissions.
- Provide public education and information about options for reducing motor vehicle-related greenhouse gas emissions. Include information on trip reduction; trip linking; public transit; biking and walking; vehicle performance and efficiency (*e.g.*, keeping tires inflated); low or zero-emission vehicles; and car and ride sharing.

**Housing**[59]

- Improve the jobs-housing balance and promote a range of affordable housing choices near jobs, services and transit to reduce vehicle miles traveled.

**Open Space**[60]

- Preserve forested areas, agricultural lands, wildlife habitat and corridors, wetlands, watersheds, groundwater recharge areas and other open space that provide carbon sequestration benefits.
- Establish a mitigation program for development of open space. Impose mitigation fees on development of such lands and use funds generated to protect existing, or create replacement, open space.
- Allow alternative energy projects in areas zoned for open space where consistent with other uses and values.
- Protect existing trees and encourage the planting of new trees. Adopt a tree protection and replacement ordinance, *e.g.*, requiring that trees larger than a specified diameter that are removed to accommodate development must be replaced at a set ratio.
- Connect parks and publicly accessible open space through shared pedestrian/bike paths and trails to encourage walking and bicycling.

**Safety**[61]

- Address expected effects of climate change that may impact public safety, including increased risk of wildfires, flooding and sea level rise, salt water intrusion; and health effects of increased heat and ozone, through appropriate policies and programs.
- Adopt land use designations that restrict or prohibit development in areas that may be more severely impacted by climate change, *e.g.*, areas that are at high risk of wildfire, sea level rise, or

flooding.

- Adopt programs for the purchase, transfer or extinguishment of development rights in high risk areas.
- Monitor the impacts of climate change. Use adaptive management to develop new strategies, and modify existing strategies, to respond to the impacts of climate change.

**(3) Resources**

The following web sites and organizations provide general information about mitigating global warming impacts at the local level. These sites represent only a small fraction of the available resources. Local agencies are encouraged to conduct their own research in order to obtain the most current and relevant materials.

- The Institute for Local Government (ILG) maintains a list of local agencies that have Climate Action Plans. The list is available here: http://www.cacities.org/index.jsp?zone=ilsg&previewStory=27035. According to ILG, the list includes Marin County and the cities of Arcata, Berkeley, Los Angeles, Palo Alto, San Diego, and San Francisco. Many additional local governments are in the process of conducting greenhouse gas inventories.

- The U.S. Conference of Mayors' Climate Protection Agreement contains valuable information for the many local agencies that are joining the fight against global warming. The Agreement is available here: http://www.coolcities.us/resources/bestPracticeGuides/USM_ClimateActionHB.pdf. Over one hundred and twenty California cities have joined the "Cool Cities" campaign, which means they have signed the U.S. Mayor's Climate Protection Agreement and are taking concrete steps toward addressing global warming. These steps include preparing a city-wide greenhouse gas emissions inventory and creating and implementing a local Climate Action Plan. Additional resources, including various cities' Climate Action Plans, are located at the Cool Cities website: http://www.coolcities.us/resources.php.

- In July 2007, Alameda County became one of twelve charter members of the "Cool Counties" initiative. Participating counties sign a Climate Stabilization Declaration, which is available at the website for King County (Washington State): http://www.metrokc.gov/exec/news/2007/0716dec.aspx. Participating counties agree to work with local, state, and federal governments and other leaders to reduce county geographical greenhouse gas emissions to 80% below current levels by 2050 by developing a greenhouse gas emissions inventory and regional reduction plan. Current member counties are recruiting new members and are committed to sharing information. Cool Counties contact information is available at: http://www.kingcounty.gov/exec/coolcounties/Joinus.aspx.

- Local Governments for Sustainability, a program of International Cities for Local Environmental Initiatives (ICLEI), has initiated a campaign called Cities for Climate Protection (CCP). The membership program is designed to empower local governments worldwide to take action on climate change. Many California cities have joined ICLEI. More information is available at the organization's website: http://www.iclei.org/.

- The Institute for Local Government, an affiliate of the California State Association of Counties and the

League of California Cities, has instituted a program called the California Climate Action Network (CaliforniaCAN!). The program provides information about the latest climate action resources, best practices, and case studies. More information is available at the CaliforniaCAN! website: http://www.cacities.org/index.jsp?displaytype=&section=climate&zone=ilsg.

- The Governor's Office of Planning and Research provides valuable resources for lead agencies related to CEQA and global warming at http://opr.ca.gov/index.php?a=ceqa/index.html. Among the materials available are a list of environmental documents addressing climate change and greenhouse gas emissions and a list of local plans and policies addressing climate change.

- The California Air Pollution Control Officers Association has prepared a white paper entitled "CEQA and Climate Change" (January 2008). The document includes a list of mitigation measures and information about their relative efficacy and cost. The document is available at http://www.capcoa.org/ceqa/?docID=ceqa.

- The Attorney General's global warming website includes a section on CEQA. See http://ag.ca.gov/globalwarming/ceqa.php. The site includes all of the Attorney General's public comment letters that address CEQA and global warming.

For information on the general plan process, see Governor's Office of Planning and Research, General Plan Guidelines (1998), available at http://ceres.ca.gov/planning/genplan/gpg.pdf.

## (4) Endnotes

1. Energy efficiency leads the mitigation list because it promises significant greenhouse gas reductions through measures that are cost-effective for the individual residential and commercial energy consumer.

2. Leadership in Energy and Environmental Design (LEED) administers a Green Building Ratings program that provides benchmarks for the design, construction, and operation of high-performance green buildings. More information about the LEED ratings system is available at http://www.usgbc.org/DisplayPage.aspx?CategoryID=19. Build it Green is a non-profit, membership organization that promotes green building practices in California. The organization offers a point-based, green building rating system for various types of projects. See http://www.builditgreen.org/guidelines-rating-systems. Lawrence Berkeley National Laboratories' Building Technologies Department is working to develop coherent and innovative building construction and design techniques. Information and publications on energy efficient buildings are available at the Department's website at http://btech.lbl.gov.

3. For more information, see Lawrence Berkeley National Laboratories, Heat Island Group at http://eetd.lbl.gov/HeatIsland/.

4. See California Energy Commission, "How to Hire an Energy Services Company" (2000) at http://www.energy.ca.gov/reports/efficiency_handbooks/400-00-001D.PDF.

5. Energy Star is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy that certifies energy efficient products and provides guidelines for energy efficient practices for homes and businesses. More information about Energy Star-certified products is available at http://www.energystar.gov/. The Electronic Product Environmental Assessment Tool (EPEAT) is a system that ranks computer products based on their conformance to a set of environmental criteria, including energy efficiency. More information about EPEAT is available at http://www.epeat.net/AboutEPEAT.aspx.

6. LED lighting is substantially more energy efficient than conventional lighting and can save money. See http://www.energy.ca.gov/efficiency/partnership/case_studies/TechAsstCity.pdf (noting that installing LED traffic signals saved the City of Westlake about $34,000 per year). As of 2005, only about a quarter of California's cities and counties were using 100% LEDs in traffic signals. See California Energy Commission (CEC), Light Emitting Diode Traffic Signal Survey (2005) at p. 15, available at http://www.energy.ca.gov/2005publications/CEC-400-2005-003/CEC-400-2005-003.PDF. The CEC's Energy Partnership Program can help local governments take advantage of energy saving technology, including, but not limited to, LED traffic signals. See http://www.energy.ca.gov/efficiency/partnership/.

7. See Palm Desert Energy Partnership at http://www.sce.com/rebatesandsavings/palmdesert. The City, in partnership with Southern California Edison, provides incentives and rebates for efficient equipment. See Southern California Edison, Pool Pump and Motor Replacement Rebate Program at http://www.sce.com/RebatesandSavings/Residential/_Pool/PoolPumpandMotor/.

8. Many cities and counties provide energy efficiency education. See, for example, the City of Stockton's Energy Efficiency website at http://www.stocktongov.com/energysaving/index.cfm. See also "Green County San Bernardino," http://www.greencountysb.com/ at pp. 4-6. Private projects may also provide education. For example, a homeowners' association could provide information and energy audits to its members on a regular basis.

9. See http://www.gosolarcalifornia.ca.gov/documents/CEC-300-2007-008-CMF.PDF. At the direction of Governor Schwarzenegger, the California Public Utilities Commission (CPUC) approved the California Solar Initiative on January 12, 2006. The initiative creates a $3.3 billion, ten-year program to install solar panels on one million roofs in the State. See http://www.gosolarcalifornia.ca.gov/nshp/index.html.

10. For example, Alameda County has installed two solar tracking carports, each generating 250 kilowatts. By 2005, the County had installed eight photovoltaic systems totaling over 2.3 megawatts. The County is able to meet 6 percent of its electricity needs through solar power. See http://www.acgov.org/gsa/Alameda%20County%20-%20Solar%20Case%20Study.pdf.

11. Many commercial, industrial, and campus-type facilities (such as hospitals, universities and prisons) use fuel to produce steam and heat for their own operations and processes. Unless captured, much of this heat is wasted. Combined heat and power (CHP) captures waste heat and re-uses it, *e.g.*, for residential or commercial space heating or to generate electricity. See U.S. EPA, Catalog of CHP Technologies at http://www.epa.gov/chp/documents/catalog_of_%20chp_tech_entire.pdf. The average efficiency of fossil-fueled power plants in the United States is 33 percent. By using waste heat recovery technology, CHP systems typically achieve total system efficiencies of 60 to 80 percent. CHP can also substantially reduce emissions of carbon dioxide. http://www.epa.gov/chp/basic/efficiency.html. Currently, CHP in California has a capacity of over 9 million kilowatts. See list of California CHP facilities at http://www.eea-inc.com/chpdata/States/CA.html.

12. The California Energy Commission has found that the State's water-related energy use – which includes the conveyance, storage, treatment, distribution, wastewater collection, treatment, and discharge – consumes about 19 percent of the State's electricity, 30 percent of its natural gas, and 88 billion gallons of diesel fuel every year, and this demand is growing. See http://www.energy.ca.gov/2007publications/CEC-999-2007-008/CEC-999-2007-008.PD

F. Accordingly, reducing water use and improving water efficiency can help reduce energy use and associated greenhouse gas emissions.

13. The Water Conservation in Landscaping Act of 2006 (AB 1881) requires the Department of Water Resources (DWR), not later than January 1, 2009, to update the Model Water Efficient Landscape Ordinance. The draft of the entire updated Model Water Efficient Landscape Ordinance will be made available to the public. See http://www.owue.water.ca.gov/landscape/ord/updatedOrd.cfm.

14. See Graywater Guide, Department of Water Resources, Office of Water Use Efficiency and Transfers at http://www.owue.water.ca.gov/docs/graywater_guide_book.pdf. See also The Ahwahnee Water Principles, Principle 6, at http://www.lgc.org/ahwahnee/h2o_principles.html. The Ahwahnee Water Principles have been adopted by City of Willits, Town of Windsor, Menlo Park, Morgan Hill, Palo Alto, Petaluma, Port Hueneme, Richmond, Rohnert Park, Rolling Hills Estates, San Luis Obispo, Santa Paula, Santa Rosa, City of Sunnyvale, City of Ukiah, Ventura, Marin County, Marin Municipal Water District, and Ventura County.

15. See Office of Environmental Health Hazard Assessment and the California Water and Land Use Partnership, Low Impact Development, at http://www.coastal.ca.gov/nps/lid-factsheet.pdf.

16. See, for example, the City of Santa Cruz, Water Conservation Office at http://www.ci.santa-cruz.ca.us/wt/wtcon/index.html; Santa Clara Valley Water District, Water Conservation at http://www.valleywater.org/conservation/index.shtm; and Metropolitan Water District and the Family of Southern California Water Agencies, Be Water Wise at http://www.bewaterwise.com. Private projects may provide or fund similar education.

17. See CEC Public Interest Energy Research Program, Dairy Power Production Program, Dairy Methane Digester System, 90-Day Evaluation Report, Eden Vale Dairy (Dec. 2006) at http://www.energy.ca.gov/2006publications/CEC-500-2006-083/CEC-500-2006-083.PDF. See also discussion in the general plan section, below, relating to wastewater treatment plants and landfills.

18. Many cities and counties provide information on waste reduction and recycling. See, for example, the Butte County Guide to Recycling at http://www.recyclebutte.net. The California Integrated Waste Management Board's website contains numerous publications on recycling and waste reduction that may be helpful in devising an education project. See http://www.ciwmb.ca.gov/Publications/default.asp?cat=13. Private projects may also provide education directly, or fund education.

19. See U.S. EPA, Our Built and Natural Environments, A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality (Jan. 2001) at

pp. 46-48 http://www.epa.gov/dced/pdf/built.pdf.

20. The U.S. Conference of Mayors cites Sacramento's Transit Village Redevelopment as a model of transit-oriented development. More information about this project is available at http://www.cityofsacramento.org/planning/projects/65th-street-village/. The California Department of Transportation maintains a searchable database of 21 transit-oriented developments at http://transitorienteddevelopment.dot.ca.gov/miscellaneous/NewHome.jsp.

21. Palo Alto's Green Ribbon Task Force Report on Climate Protection recommends pedestrian and bicycle-only streets sections under its proposed actions. See http://www.city.palo-alto.ca.us/civica/filebank/blobdload.asp?BlobID=7478.

22. There are a number of car sharing programs operating in California, including City CarShare http://www.citycarshare.org/, Zip Car http://www.zipcar.com/ and Flexcar http://www.flexcar.com/.

23. The City of Lincoln has a NEV program. See http://www.lincolnev.com/index.html.

24. See, for example, Marin County's Safe Routes to Schools program at http://www.saferoutestoschools.org/.

25. The Conservation Element addresses the conservation, development, and use of natural resources including water, forests, soils, rivers, and mineral deposits. Measures proposed for the Conservation Element may alternatively be appropriate for other elements. In practice, there may be substantial overlap in the global warming mitigation measures appropriate for the Conservation and Open Space Elements.

26. See the Attorney General's settlement agreement with the County of San Bernardino, available at http://ag.ca.gov/cms_pdfs/press/2007-08-21_San_Bernardino_settlement_agreement.pdf. See also Marin County Greenhouse Gas Reduction Plan (Oct. 2006) at http://www.co.marin.ca.us/depts/CD/main/pdf/final_ghg_red_plan.pdf; Marin Countywide Plan (Nov. 6, 2007) at http://www.co.marin.ca.us/depts/CD/main/fm/cwpdocs/CWP_CD2.pdf; Draft Conservation Element, General Plan, City of San Diego at http://www.sandiego.gov/planning/genplan/pdf/generalplan/ce070918.pdf.

27. Public Resources Code Section 25402.1(h)2 and Section 10-106 of the Building Energy Efficiency Standards establish a process that allows local adoption of energy standards that are more stringent than the statewide Standards. More information is available at the California Energy Commission's website. See http://www.energy.ca.gov/title24/2005standards/ordinances_exceeding_2005_building_standards.html.

28. See, *e.g.*, LEED at http://www.usgbc.org/DisplayPage.aspx?CategoryID=19; see also Build it Green at http://www.builditgreen.org/guidelines-rating-systems.

29. The City of Santa Monica, for example, has instituted a Green Building Program. See http://www.greenbuildings.santa-monica.org/. The City of Pasadena also has a green building ordinance that applies to public and private buildings. See http://www.ci.pasadena.ca.us/permitcenter/greencity/building/gbprogram.asp and http://ordlink.com/codes/pasadena/index.htm?Search_Code=Begin+Searching+Municipal+Code at Title 14. The City of San Francisco is considering adopting green building performance requirements that would apply to public and private buildings. See http://www.sfenvironment.org/downloads/library/gbtfrrreleasev1.3.pdf.

30. See, *e.g.*, "Green County San Bernardino," http://www.greencountysb.com/. As part of its program, the County is waiving permit fees for alternative energy systems and efficient heating and air conditioning systems. See http://www.greencountysb.com/ at p. 3. For a representative list of incentives for green building offered in California and throughout the nation, see U.S. Green Building Council, Summary of Government LEED Incentives (updated quarterly) at https://www.usgbc.org/ShowFile.aspx?DocumentID=2021.

31. For example, Riverside Public Utilities offers free comprehensive energy audits to its business customers. See http://www.riversideca.gov/utilities/busi-technicalassistance.asp.

32. Under Southern California Gas Company's Energy Efficiency Program for Commercial/Industrial Large Business Customers, participants are eligible to receive an incentive based on 50% of the equipment cost, or $0.50 per therm saved, whichever is lower, up to a maximum amount of $1,000,000 per customer, per year. Eligible projects require an energy savings of at least 200,000 therms per year. See http://www.socalgas.com/business/efficiency/grants/.

33. The City of Berkeley is in the process of instituting a "Sustainable Energy Financing District." According to the City, "The financing mechanism is loosely based on existing 'underground utility districts' where the City serves as the financing agent for a neighborhood when they move utility poles and wires underground. In this case, individual property owners would contract directly with qualified private solar installers and contractors for energy efficiency and solar projects on their building. The City provides the funding for the project from a bond or loan fund that it repays through assessments on participating property owners' tax bills for 20 years." See http://www.cityofberkeley.info/Mayor/PR/pressrelease2007-1023.htm.

34. As described in its Climate Action Plan, the City of San Francisco uses a combination of incentives and technical assistance to reduce lighting energy use in small businesses such as grocery stores, small retail outlets, and restaurants. The program offers free energy audits and coordinated lighting retrofit installation. In addition, the City offers residents

the opportunity to turn in their incandescent lamps for coupons to buy fluorescent units. See San Francisco's Climate Action Plan, available at http://www.sfenvironment.org/downloads/library/climateactionplan.pdf.

35. Among other strategies for reducing its greenhouse gas emissions, Yolo County has adopted purchasing policies for computers and electrical equipment. http://www.yolocounty.org/docs/press/GreenhouseGas.htm.

36. See, for example, Los Angeles County Green Purchasing Policy, June 2007 at http://www.responsiblepurchasing.org/UserFiles/File/General/Los%20Angeles%20County,%20Green%20Purchasing%20Policy,%20June%202007.pdf. The policy requires County agencies to purchase products that minimize environmental impacts, including greenhouse gas emissions.

37. Some local agencies have implemented a cool surfaces programs in conjunction with measures to address storm water run off and water quality. See, for example, The City of Irvine's Sustainable Travelways/Green Streets program at http://www.cityofirvine.org/depts/redevelopment/sustainable_travelways.asp; The City of Los Angeles's Green Streets LA program at http://water.lgc.org/water-workshops/la-workshop/Green_Streets_Daniels.pdf/view; see also The Chicago Green Alley Handbook at http://egov.cityofchicago.org/webportal/COCWebPortal/COC_EDITORIAL/GreenAlleyHandbook_Jan.pdf.

38. See the website for Lawrence Berkeley National Laboratory's Urban Heat Island Group at http://eetd.lbl.gov/HeatIsland/LEARN/ and U.S. EPA's Heat Island website at www.epa.gov/heatisland/. To learn about the effectiveness of various heat island mitigation strategies, see the Mitigation Impact Screening Tool, available at http://www.epa.gov/heatisld/resources/tools.html.

39. For example, the City of Lompoc has a policy to "require new development to offset new water demand with savings from existing water users, as long as savings are available." See http://www.ci.lompoc.ca.us/departments/comdev/pdf07/RESRCMGMT.pdf.

40. The Irvine Ranch Water District in Southern California, for example, uses a five-tiered rate structure that rewards conservation. The water district has a baseline charge for necessary water use. Water use that exceeds the baseline amount costs incrementally more money. While "low volume" water use costs $.082 per hundred cubic feet (ccf), "wasteful" water use costs $7.84 per ccf. See http://www.irwd.com/AboutIRWD/rates_residential.php. Marin County has included tiered billing rates as part of its general plan program to conserve water. See Marin County Countywide Plan, page 3-204, PFS-2.q, available at http://www.co.marin.ca.us/depts/CD/main/fm/cwpdocs/CWP_CD2.pdf.

41. See the City of Fresno's Watering Regulations and Ordinances at http://www.fresno.gov/Government/DepartmentDirectory/PublicUtilities/Watermanagement/Conservation/WaterRegulation/WateringRegulationsandRestrictions.htm.

42. See, *e.g.*, the City of San Diego's plumbing retrofit ordinance at http://www.sandiego.gov/water/conservation/selling.shtml.

43. The City of Roseville offers free water conservation audits through house calls and on-line surveys. See http://www.roseville.ca.us/eu/water_utility/water_conservation/for_home/programs_n_rebates.asp.

44. See Landscape Performance Certification Program, Municipal Water District of Orange County at http://waterprograms.com/wb/30_Landscapers/LC_01.htm.

45. For example, San Diego's Metropolitan Wastewater Department (SDMWD) installed eight digesters at one of its wastewater treatment plants. Digesters use heat and bacteria to break down the organic solids removed from the wastewater to create methane, which can be captured and used for energy. The methane generated by SDMWD's digesters runs two engines that supply enough energy for all of the plant's needs, and the plant sells the extra energy to the local grid. See http://www.sandiego.gov/mwwd/facilities/ptloma.shtml. In addition, the California Air Resources Board approved the Landfill Methane Capture Strategy as an early action measure. http://www.arb.ca.gov/cc/ccea/landfills/landfills.htm. Numerous landfills in California, such as the Puenta Hills Landfill in Los Angeles County (http://www.lacsd.org/about/solid_waste_facilities/puente_hills/clean_fuels_program.asp) the Scholl Canyon Landfill in the City of Glendale (http://www.glendalewaterandpower.com/Renewable%20Energy%20Development.asp), and theYolo Landfill in Yolo County, are using captured methane to generate power and reduce the need for other more carbon-intensive energy sources.

46. On April 30, 2007, the Public Utilities Commission authorized a CCA application by the Kings River Conservation District on behalf of San Joaquin Valley Power Authority (SJVPA). SJVPA's Implementation Plan and general CCA program information is available at www.communitychoice.info. See also http://www.co.marin.ca.us/depts/CD/main/comdev/advance/Sustainability/Energy/cca/CCA.cfm. (County of Marin); and http://sfwater.org/mto_main.cfm/MC_ID/12/MSC_ID/138/MTO_ID/237 (San Francisco Public Utilities Commission).

47. The Land Use Element designates the type, intensity, and general distribution of uses of land for housing, business, industry, open-space, education, public buildings and grounds, waste disposal facilities, and other categories of public and private uses.

48. Samples of local legislation to reduce sprawl are set forth in the U.S. Conference of Mayors' Climate Action Handbook. See http://www.iclei.org/documents/USA/documents/CCP/Climate_Action_Handbook-0906.pdf.

49. The City of Berkeley has endorsed the strategy of reducing developer fees or granting property tax credits for mixed-use developments in its Resource Conservation and Global Warming Abatement Plan. City of Berkeley's Resource Conservation and Global Warming Abatement Plan p. 25 at http://www.baaqmd.gov/pln/GlobalWarming/BerkeleyClimateActionPlan.pdf.

50. For a lists and maps related to urban growth boundaries in California, see Urban Growth Boundaries and Urban Line Limits, Association of Bay Area Governments (2006) at http://www.abag.ca.gov/jointpolicy/Urban%20Growth%20Boundaries%20and%20Urban%20Limit%20Lines.pdf**.**

51. The Circulation Element works with the Land Use element and identifies the general location and extent of existing and proposed major thoroughfares, transportation routes, terminals, and other local public utilities and facilities.

52. See Orange County Transportation Authority, Signal Synchronization at http://www.octa.net/signals.aspx. Measures such as signal synchronization that improve traffic flow must be paired with other measures that encourage public transit, bicycling and walking so that improved flow does not merely encourage additional use of private vehicles.

53. San Francisco's "Transit First" Policy is listed in its Climate Action Plan, available at http://www.sfenvironment.org/downloads/library/climateactionplan.pdf. The City's policy gives priority to public transit investments and provides public transit street capacity and discourages increases in automobile traffic. This policy has resulted in increased transit service to meet the needs generated by new development.

54. The City of La Mesa has a Sidewalk Master Plan and an associated map that the City uses to prioritize funding. As the City states, "The most important concept for sidewalks is connectivity. For people to want to use a sidewalk, it must conveniently connect them to their intended destination." See http://www.ci.la-mesa.ca.us/index.asp?NID=699.

55. San Francisco assesses a Downtown Transportation Impact Fee on new office construction and commercial office space renovation within a designated district. The fee is discussed in the City's Climate Action plan, available at http://www.sfenvironment.org/downloads/library/climateactionplan.pdf.

56. For example, Seattle, Washington maintains a public transportation "ride free" zone in its downtown from 6:00 a.m. to 7:00 p.m. daily. See http://transit.metrokc.gov/tops/accessible/paccessible_map.html#fare.

57. Reforming Parking Policies to Support Smart Growth, Metropolitan Transportation Commission (June 2007) at http://www.mtc.ca.gov/planning/smart_growth/parking_seminar/Toolbox-Handbook.pdf.

58. See Safe Routes to School Toolkit, National Highway Traffic Safety Administration (2002) at www.nhtsa.dot.gov/people/injury/pedbimot/bike/Safe-Routes-2002; see also www.saferoutestoschools.org (Marin County).

59. The Housing Element assesses current and projected housing needs. In addition, it sets policies for providing adequate housing and includes action programs for that purpose.

60. The Open Space Element details plans and measures for preserving open space for natural resources, the managed production of resources, outdoor recreation, public health and safety, and the identification of agricultural land. As discussed previously in these Endnotes, there may be substantial overlap in the measures appropriate for the Conservation and Open Space Elements.

61. The Safety Element establishes policies and programs to protect the community from risks associated with seismic, geologic, flood, and wildfire hazards.